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CARCINOMA OF THE UTERINE CERVIX TREATED WITH 400 KV. ROENTGEN RAYS AND RADIUM*

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THE treatment of 60 cases of carcinoma of the cervix uteri seen in our office during 1935, 1936 and 1937, all of which have been traced to date, resulted as follows:

TABLE I

Year	Cases Treated	Number Living	Number Dead	Survival Rate
1935	20	6	14	5 yr.—30%
1936	27	11	16	4 yr.—40.7%
1937	14	8	6	3 yr.—57.1%

All were treated by roentgen rays generated at 400 kv., pulsating potential, and at 5 ma. The filter used has been of two types, because of changes in the tube, which was of sealed construction. At first the filter was 2 mm. of copper inherent, with 0.25 mm. of copper plus 0.4 mm. of tin and 1 mm. of aluminum added. Later the filter was 1 mm. of copper inherent, with 0.25 mm. of copper plus 0.8 mm. of tin and 1 mm. of aluminum added. The half-value layer (Glasser) was 5.2 mm. of copper. The distance used was 80 cm. The depth dose at 10 cm. was estimated at 45 per cent for a 15×15 cm. portal. The rate of emission varied with tubes, but was never far from 15 r per minute.

In some of the first cases treated four fields were used: one anterior, one posterior, and two lateral; the size of the portals 15×15 cm. Later this was changed to three fields: one anterior, one posterior, and one perineal; the anterior and posterior portals remaining at 15×15 cm. and the perineal portal varying from 7.5×7.5 cm. to 10×10 cm. The 10×10 cm. perineal portal is now used routinely. Only one field per day was treated and the daily dose was usually 200 r, never more. When the bowel symptoms or the general condition of the patient demanded it, the daily dose was lowered to 150 r.

The method of application was as follows: The patient was treated over the anterior and posterior areas on alternate days through a 15×15 cm. portal until the total dose to these fields was given. The patient was then treated daily over the perineal area. The time required for the entire procedure was about forty elapsed days.

The average amount of roentgen radiation varied from 2,500 r to 2,850 r, measured in air, to each of the anterior and posterior portals, and 1,800 r over the perineal portal. No attempt has been made to measure the tumor dose. The effect on the bowel was the factor which determined

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the total dose. Until it became evident that permanent damage to the bowel mucosa might result, the anteroposterior fields were

TABLE II

ANALYSIS OF RESULTS 1935

Stage	No. Cases	Cases per cent		No. Alive	No. Dead	Survival per cent	
I	1	5		1	0	100	
II	2	10		2	0	100	
III	2	10	85	0	2	0	17.5
IV	15	75		3	12	20	
All stages	20	100		6	14	30	

One case has definite recurrent cancer in the pelvis. Four of these cases were so far advanced, the roentgen treatment was given only for palliation. No radium was used. One of the 4 only received about one-third of the usual amount of roentgen radiation. All were dead within five months.

continued and then the perineal field was given. The skin reaction was not a factor in the control of dosage. The reaction, while sharp, healed quickly, with little secondary change.

In some of these cases roentgen irradiation was given before the radium was used. In these cases, by the time the skin reaction subsided, usually in about three weeks, vaginal examination revealed very little evidence of the original lesion. As a rule, the radium was not used until the skin had healed. We have not decided definitely that giving the roentgen radiation first has any advantage.

In some cases where the roentgen radiation was used first, there was a tendency, because of the improvement noted in the gross appearance, to reduce the dose of radium. This we believe to be a mistake. We feel that at least 4,000 milligram-hours should be used, the distribution of the applicators and methods of application to be suited to each individual case.

In classifying the stages of the disease in the cases we have reported, we have attempted to follow the method of Schmitz. We realize, however, that some variations may be made in our clinical grouping.

COMPLICATIONS

Diarrhea. This varies greatly. Some patients develop it early in the second week of treatment, at which time it may often be controlled by lowering the daily dose, plus the administration of a few doses of paregoric.

This early diarrhea is rarely severe, and is not an indication for discontinuing the treatment. Later in the course of treatment, in the fourth week, diarrhea will again appear. This can be controlled by larger doses of paregoric for a few days, but treatment must soon be stopped, or serious damage to the bowel will occur. This diarrhea is often accompanied by crampy pains which are not usually severe, but do cause some trouble and anxiety.

In the literature necrosis of the small bowel has been reported. This we have not encountered. It is our belief that a bowel damaged by previous irradiation will explain most of these cases.

Skin Reaction. This is no longer an important or controlling factor. The use of a divided dose technique, heavier filters, and perhaps the use of higher voltages, permits the continuation of the treatment to a total dose that often produces extensive primary

TABLE III

ANALYSIS OF RESULTS 1936

Stage	No. Cases	Cases per cent		No. Alive	No. Dead	Survival per cent	
I	2	7.4		2	0	100	
II	4	14.7		2	2	50	
III	8	29.8	78	4	4	50	33
IV	13	48.1		3	10	23	
All stages	27	100		11	16	40.7	

Two of these cases were so far advanced roentgen irradiation was given only for palliation. No radium was used. Both of these cases died within six months.

skin change. These reactions end in complete healing. Observation of the skin, irradiated with the above technique, over a period of five years has shown little secondary change. There may be some lymphatic stasis and some thickening of the skin, slight but not marked telangiectasia with a complete loss of pubic hair, but in no instance has the patient complained from these late effects on the skin.

Radiation Sickness. The nausea and vomiting from radiation sickness are not important factors. The use of small daily doses makes it possible, by careful attention to diet and the forcing of food when nausea does occur, to continue with little and often no untoward effects. There is, however, a reaction, a systemic one, which occurs in some patients, usually in those already debilitated. Its main manifestations are a loss of strength and appetite, and a general breakdown. The exact cause of this we do not know. It is, however, a far more serious complication than nausea. We have been able to control this fairly well by the use of liver extract, 1 cc. given intramuscularly each day.

Vaginal adhesions occur in all cases. These are the result of the reaction on the vaginal mucosa, which is usually quite intense. By frequent introduction of a speculum these adhesions may be prevented from becoming permanent. However, in some patients a marked narrowing of the vagina occurs. This is due to a late pelvic fibrosis, and is most marked when the disease has been extensive. This pelvic fibrosis has not produced serious symptoms in our cases, nor has this fibrosis involved the ureters so that clinical symptoms have resulted. The principal complication of pelvic fibrosis is fixation of the pelvic structures. This fixation makes it difficult to determine whether residual tumor or recurrent disease is present.

Bladder symptoms have been few, and most of them mild, and quickly relieved by simple remedies. A very recent case developed an ulcer which had the appearance of a malignant change. However, sections showed it to be inflammatory, and it healed rapidly under treatment by a urologist.

Vesicovaginal and rectovaginal fistulae have occurred in some of the patients who have died. Rectovaginal fistula also occurred in one patient who has survived. This was a small opening which persisted for some time, but has closed spontaneously.

None of our cases has shown fracture of the femur such as are reported in the literature. One of the most annoying, but not serious complications has been that of the changes in the rectum and pelvic colon which occur three to six months following completion of the treatment. The patient complains of frequent, small stools containing mucus and some blood. Tenesmus is present. The anterior wall of the rectum and pelvic colon show an injected mucosa with numerous small ulcerated areas. These symptoms are relieved by cleansing and soothing enemas. No permanent rectal damage has occurred in any of the cases reported.*

TABLE IV

ANALYSIS OF RESULTS 1937

Stage	No. Cases	Cases per cent		No. Alive	No. Dead	Survival per cent	
I	2	14.2		2	0	100	
II	3	21.5		3	0	100	
III	6	42.8	64.3	2	4	$33\frac{1}{3}$	$33\frac{1}{3}$
IV	3	21.5		1	2	$33\frac{1}{3}$	
All stages	14	100		8	6	57.1	

One, a Stage I, in a retained cervix after partial hysterectomy received no radium. This patient is alive without evidence of disease.

* For discussion see page 826.

CARCINOMA OF THE CERVIX UTERI

A STUDY OF 727 CASES*

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THE fact that cancer of the cervix exacts annually in this country a toll of more than 16,000 women has prompted this study of an abundant material. It is offered with the hope that our experience may be of some value in bettering the results secured from radiation therapy in the treatment of this cancer.

The material comprised in the study was obtained from the Tumor Clinic of the Shreveport Charity Hospital, a State maintained institution for indigents, of 800 beds, and from my private clinic. The great majority of the patients were seen in the Charity Hospital clinic.

TABLE I
ANATOMIC DISTRIBUTION OF 905 CASES OF CANCER OF THE FEMALE GENERATIVE TRACT, JULY 2, 1932 TO APRIL 30, 1940

Location of Carcinoma	Number of Cases
Cervix	727
Corpus of uterus	67
Ovary	52
Vulva	34
Vagina	13
Sarcoma of uterus	10
Chorionepithelioma	2
GRAND TOTAL	905

The study covers a period of nearly eight years, from July 2, 1932, to April 30, 1940. During this time 905 cases of cancer of the female genital tract were seen. The anatomical distribution of the lesions is shown in Table 1. Carcinoma of the cervix of the uterus accounts for 727 cases, or 80 per cent of the total. A study of the annual admissions reveals that an average of 93 new patients with cervical cancer have been admitted to the Tumor Clinic each year. Two hundred and sixty-five of the patients were white, 462 were Negro. The youngest patient was eighteen years of age, the oldest was eighty-three.

Biopsies were carried out on all but 26 of the patients. Six hundred and seventy of the cancers were epidermoid carcinomas. Four hundred and thirty-five were of Grade 2; 172 of Grade 3; 21 of Grade 4, and 42 were not graded. There were 31 adenocarcinomas.

Clinically, the cases have been grouped according to the League of Nations classification, which is as follows:

Stage I. Disease limited to cervix; uterus mobile.

Stage II. Disease spreading into fornices with or without infiltration adjacent to uterus; uterus partially mobile.

Stage III. (a) Nodular infiltration of parametrium extending to wall of pelvis, with limited mobility of uterus or massive infiltration of parametrium with fixed uterus.

(b) Superficial infiltration of large part of vagina, with mobile uterus.

(c) Isolated metastases in pelvic glands with relatively small primary growth.

(d) Isolated metastases in lower part of vagina.

Stage IV. (a) Massive infiltration of both parametria extending to walls of pelvis.

(b) Disease involving bladder or rectum.

(c) Whole vagina infiltrated, or one vaginal wall entirely infiltrated with fixation of primary growth.

(d) Remote metastases.

In the material of this study 63 cases were, at the beginning of treatment, in Stage 1 of the above clinical classification of the stage of the disease, 126 in Stage

* Read at the Twenty-fifth Annual Meeting, American Radium Society, New York, N. Y., June 10–11, 1940.

TABLE II

CARCINOMA OF CERVIX. CLINICAL GROUPING

Clinical Classification	Year of Admittance									
	1932	1933	1934	1935	1936	1937	1938	1939	1940	Total
Carcinoma of cervix, Stage I	2	6	6	3	15	8	9	8	6	63
Carcinoma of cervix, Stage II	10	13	16	15	18	16	16	14	8	126
Carcinoma of cervix, Stage III	7	24	17	21	36	27	27	17	5	181
Carcinoma of cervix, Stage IV	20	35	33	43	33	56	57	58	22	357
TOTAL	39	78	72	82	102	107	109	67	41	727

II, 181 in Stage III, and 357 in Stage IV.

Table II shows admissions year by year for each of the four stages. It is not possible to find in this table any definite trend in the distribution of cases between the different stages; in other words, it yields no evidence that we are seeing our cases of cancer of the cervix at an earlier stage of the disease.

On admission to the Tumor Clinic every patient received a complete physical examination, including blood examination and urological survey when possible; it has been our goal that this urological survey should include pyelographic study of the kidneys. When indicated, special investigation of the chest and gastrointestinal tract has been made. As already stated, a biopsy study was done on nearly every case.

Of the 727 patients seen, only 40 received no treatment. The reason for no treatment in these cases was either the unsatisfactory condition of the patient or her desertion from the hospital.

The majority of the patients in this study were subjected to the intensive plan of high voltage roentgen treatment, employing from four to six pelvic fields, with doses ranging from 1,200 r/o to 2,400 r/o to each field. I shall presently briefly discuss this plan of treatment.

Three hundred and twenty-two patients, that is approximately 44 per cent of the total group or 47 per cent of the number of patients treated, received radium therapy in addition to high voltage roentgen treatment. The radium application followed immediately after the completion of the series of roentgen exposures. Treatment was based on the following general plan: The radium is applied in the cervix and vagina with a modified type of Regaud applicator. In the cervix and uterine canal filtration is through 1 mm. of platinum; in the vaginal portion, through 1.5 mm. of platinum. The radium is applied for a total of 6,000 to 7,500 mg-hr. The applicator is held securely in position by wide gauze packs well saturated with a solution of acriflavine 1:1000 and left in place throughout the period of application of the radium, which is from four to five days.

However, no single type of applicator can be used in all cases, and, as Arneson points out, no single dosage standard is possible. Very frequently it is not possible to use the colpostat because of contraction or infiltration in the upper vault. In a large number of patients the three corks cannot be used and for this reason I prefer to use the Clark type of cross-arm applicator along with a two-cork colpostat. Sometimes two corks cannot be used and only one central cork is employed. Frequently a London-type of vaginal applicator, which consists of three or four smaller corks, may be used to advantage. Certain bulky carcinomas of our series were first treated with the interstitial implantation of monel radium needles, making use of the caustic beta rays and bringing about a more rapid reduction of the tumor mass.

The intensive protracted application of fractional roentgen-ray doses to the pelvis

TABLE III

CARCINOMA OF CERVIX. SURVIVAL ANALYSIS—727 CASES

Clinical Classification	Year of Admission																	
	1932		1933		1934		1935		1936		1937		1938		1939		1940	
	No. of Cases	Survivals	No. of Cases	Survivals	No. of Cases	Survivals	No. of Cases	Survivals	No. of Cases	Survivals	No. of Cases	Survivals	No. of Cases	Survivals	No. of Cases	Survivals	No. of Cases	Survivals
Stage I	2	0	6	4	6	3	3	1	15	11	8	7	9	7	8	7	6	6
Stage II	10	2	13	4	16	12	15	10	18	8	16	8	16	13	14	13	8	8
Stage III	7	3	24	5	17	5	21	3	36	12	27	10	27	19	17	16	5	5
Stage IV	20	0	35	0	33	0	43	0	33	0	56	3	57	11	58	23	22	20
TOTAL CASES	39	5	78	13	72	20	82	14	102	31	107	28	109	50	97	59	41	39

is calculated to produce approximately 4 to 7 erythema doses in the parametrium and, when supplemented by the radium application, from 15 to 25 erythema doses at the cervix and in the surrounding 5 cm. of tissue.

Our autopsies on patients dying from cancer of the cervix show that many patients have had the disease cured or arrested in the pelvis or treated areas and have died from the results of metastatic nodes above the brim of the pelvis, confirming statements in the literature to the effect that the spread of lymph node metastasis is manifested beyond the iliac crests, beyond the irradiated pelvis in approximately 10 per cent of cases and that the lumbar aortic nodes and glands over the common iliac vessels are the glands involved below the diaphragm. This has led me to employ an original plan, that of irradiating the para-aortic lymphatic area. This series of high voltage roentgen treatments has usually been instituted two months after the irradiation of the cervix and pelvis. Two anterior and two posterior fields are irradiated, from below the diaphragm to the iliac spine.

Results as shown by survival appear in Table III for each stage separately and for the admissions of each year, for the entire group of 727 patients. Table IV shows the

TABLE IV

CARCINOMA OF CERVIX—SEVEN, SIX, AND FIVE YEAR SURVIVALS

Clinical Classification	1932 to 1940 Seven Year Group			1933 to 1940 Six Year Group			1934 to 1940 Five Year Group		
	Number of Patients	Number Living	Percentage Survivals	Number of Patients	Number Living	Percentage Survivals	Number of Patients	Number Living	Percentage Survivals
Stage I	2	0	0.0	6	4	66.67	6	3	50.0
Stage II	10	2	20.0	13	4	30.77	16	12	75.0
Stage III	7	3	42.86	24	5	20.83	17	5	29.41
Stage IV	20	0	0.0	35	0	0.0	33	0	0.0
TOTAL CARCINOMA OF CERVIX	39	5	12.56	78	13	16.67	72	20	27.77

survivals, for each stage, of three subgroups of patients, whose treatment dates back seven, six, and five years, respectively, a total of 189 patients. Of these 189 patients, 38, or 20.10 per cent, are alive today five or more years after admission. Fourteen of the 189 patients were in Stage I at the time of admission, 39 in Stage II, 48 in Stage III, and 88 in Stage IV. Of the 14 patients in Stage I, 7 are living; of the 39 patients in Stage II, 18 are living; of the 48 in Stage III, 13 are living; there are no survivals today of the 88 patients whose disease had advanced to Stage IV by the time it was seen by us in 1932, 1933 or 1934. Considering the seven year, six year and five year periods separately, we find, in 1940, 5 survivors among the 39 patients admitted in 1932, a seven year survival rate of 12.56 per cent; 13 survivors of the 78 patients admitted in 1933, a survival rate of 16.67; 20 survivors of the 72 patients admitted in 1934, a survival rate for the last five years of 27.77 per cent.

In Table V may be seen the mortality due to causes other than cancer. Irradiation enteritis accounted for 8 deaths, toxemia 4, peritonitis 3, second primary tumors 2, pneumonia 2, pellagra 3, hemorrhage 1. Altogether 23 of the 727 patients admitted for cancer of the cervix succumbed to some other condition. The 8 deaths from irradiation enteritis do not represent an overhigh mortality from this cause when one remembers that intensive high voltage radiation was given in large doses to a great majority of the patients.

In evaluating our results and especially in comparing them with results obtained in other sections of the country, it should be borne in mind that not only were our patients for the most part indigents, who present a different problem from that encountered in the private clinic, but the majority were of the Negro race, from which one is, in general, not able to secure as good cooperation in treatment and follow-up endeavors as from the white race. Notwithstanding the efforts of a full-time Tumor Clinic secretary and social workers along with cooperative public health units, it has in a great many cases been impossible to follow patients after they have left the hospital. In preparing this report, however, every patient who has not been traced has been regarded as having died from the disease. We regret that we are not able to report 100 per cent follow-up, as did Dr. Miller. Two further factors influencing results are that more than 75 per cent of our patients were received in an advanced stage of the disease and that the material reported on includes those patients who received no treatment because of poor condition and those who voluntarily left the hospital before treatment was completed. It is felt that the survival figures reveal the best we may expect to accomplish with radiation methods at present at our disposal in patients who are in an advanced stage of the disease.

TABLE V

CANCER OF CERVIX. MORTALITY DUE TO CAUSES OTHER THAN CANCER, JULY 2, 1932 TO APRIL 30, 1940

Cause of Death	Number of Cases
Terminal ileitis	8
Toxemia	4
Peritonitis	3
Second primary tumor	2
Pneumonia	2
Pellagra	3
Hemorrhage	1
TOTAL	23

No one will deny that progress has been made in the diagnosis and treatment of cancer of the cervix, yet a study of cases reveals that most patients come too late to be cured, not until symptoms have been present for many months. Hamant and König state some of the main causes of delay as follows: The patient does not know the symptoms of cancer and attributes the bleeding to the change of life. She is not alarmed until she notes pain, weakness, or loss of weight; seeks advice from friends,

neighbors or quacks; hesitates to see a physician for fear she may be told that she has a cancer or that she must go to a hospital. The physician fails to examine the patient or does not study her carefully. Because of inadequate training, the physician cannot recognize cancer, misses the diagnosis, gives wrong advice, and begins inappropriate treatment.

PREVENTION

The value of lay education will be denied by no one and no one will be willing to discount the tremendous effort or sincere purpose behind these programs, but cancer propangada has apparently not yet improved the material handled in my clinic. Bloodgood believed that the important means by which cures can be increased are: (1) education of women and of physicians with regard to the protective value of periodic pelvic examinations, making possible a diagnosis of early cancer before symptoms occur, at a time when a large percentage of cures may be expected; (2) training of skilled radiologists to meet the increasing demands of cancer clinics. I am in agreement that improvement can come only when cancer programs have made possible, through education, semi-annual examination of every woman over thirty-five years of age by a physician who is qualified by special training to recognize early cervical carcinoma.

Cancer of the cervix is, as a rule, preceded by chronic cervicitis. The accidents of labor and abortion frequently terminate in low grade infections of the genital organs and in such infections the vaginal portion of the cervix is always involved. Chronic infections of low grade appear to be the forerunners of cancer. To prevent cancer of the cervix a diligent search must be made for chronic infections and if any such is found adequate treatment must be instituted. Lacerations should be repaired, erosions and cysts should be cauterized. Schiller's test should be done; if positive, it may mean an erosion, a luetic ulcer, leukoplakia or carcinoma. A biopsy specimen should be taken from the area and a careful microscopic study made so that an early and correct diagnosis may be made of the lesion present.

DIAGNOSIS

It is agreed that success in treatment of cancer of the cervix depends almost entirely upon early diagnosis. Unfortunately, the symptoms of early cancer are so trivial that they fail to attract the attention of the patient. Hence it is fallacious to think that the problem of early diagnosis of cancer can be solved so long as we depend on the patient to come to us with a complaint. Leukorrhea, bleeding and pain are not symptoms of early cancer, but of a lesion that has already become firmly planted in the cervical tissue. Vaginal discharge does not appear until the cancer has grown to sufficient size to cause active congestion and increased activity of the cervical glands. Bleeding cannot and does not make its appearance until the cancerous growth has replaced a considerable amount of tissue and until ulceration has taken place. The cervix is well known to tolerate considerable damage before there is pain, which occurs only as a late symptom. When symptoms occur which the patient can recognize, cancer is already well established.

Thus it is not surprising that so few patients have an early diagnosis, for it is quite evident that *the early diagnosis of cancer of the cervix must depend on something more than the symptoms which the patient can recognize.* Early cancer findings are entirely objective and require a microscopic study for diagnosis. The early clinical appearance of cancer of the cervix is a nodule; if of the everting type, this nodule progresses to a typical cauliflower growth with necrosis and later a sloughing mass which leaves a crater behind. If the nodule is of the inverting type, it grows to considerable size and finally ulcerates, becomes secondarily infected and, as a result, leaves a large crater.

It is important to determine the clinical extent of the disease, since it is on this in-

formation that the treatment must be planned. To this end, a careful vaginal examination is necessary. Early cancer is limited to the cervix and on palpation the uterus is freely movable and the adjacent tissues present no signs of secondary inflammation. When active growth has begun in the lesion, the adjacent tissues are invaded by root-like extensions of cancer cells and infiltration into the paracervical tissues, and now the uterus is partly fixed because of the infiltration. When the invasion has extended into the parametrium, the fixation of the uterus is increased because of the loss of elasticity of the parametrial tissue. In the final stage, the entire pelvis is "frozen," showing that the disease has invaded other organs and tissues. Rectal examination will frequently convey more information in Stages II, III and IV than vaginal examination and will permit palpation of regional lymph nodes that could not be felt through the vagina. The grouping according to clinical stage—the League of Nations Classification—is recognized today in most of the gynecological clinics of the world. It is based entirely upon clinical findings and not on surgical ability. The terms operable, border line, and non-operable are obsolete and should be discarded forever. The simplicity of the classification means much to the average radiologist dealing with cancer.

PROGNOSIS

The prognosis of a given case of cancer of the cervix depends, first, on the clinical stage of the disease; second, on the age of the patient, and last but not least, on the plan of treatment. Pain is a bad prognostic sign, even in early cases. When it is referred to the back, hips and thighs, it usually indicates that the disease has already spread to the paravertebral lymph nodes.

Within the past few years much has been written about the prognostic value of the histologic grade of the tumor. At present, it may be said that the radiosensitiveness of the different histologic forms of cancer of the cervix is still unsettled, although the results which are being secured tend to support to some extent the biologic relation between anaplasia and radiosensitivity. Results secured in treatment of the four tissue groups are practically the same; there does appear a small difference between the adenocarcinoma group and the epidermoid group of marked anaplasia. Tissue grading alone seems to be of little prognostic value. On the other hand, histologic grading is of great value in determining the radiosensitivity of the tumor in determining whether or not metastasis is likely to occur. There is no indication that the adenocarcinomas are a less favorable group and that as such they should be relegated to surgery.

Healy, Schmitz, Watson, Curtis, Ward and many leading American gynecologists unhesitatingly state that surgery is not the method of choice in the treatment of cancer of the cervix. Nevertheless, there is still found an operator here and there who cannot refrain from hysterectomy in cancer of the cervix, despite the poor results which accompany it.

TREATMENT

Combined Surgery and Radium. The recent publications of Gelhorn, Curtis and Taussig, wherein they advocate coincidental surgical exposure and radium therapy, certainly represent a surgeon's dream, a radiologic nightmare, and reflect a lack of knowledge of the physics of radium therapy. Such a combination of methods is not the road to success.

Radiation Therapy. In 1913 the medical literature began to contain articles from European centers reporting splendid results obtained from application of radium in advanced cases of cancer of the cervix and vagina. So striking were the results that soon radium treatment was given to more favorable cases, and, lastly, early cases which would have been regarded as suitable for the Wertheim operation were treated with radium. From this point on, the leading gynecologists throughout the world began to employ radium in the treatment of cancer of the cervix.

There are certain factors, pointed out by Healy, which are responsible for bringing about this rapid acceptance of radium in the treatment of carcinoma of the cervix. Carcinoma of the cervix, it was known, has the peculiar characteristic of remaining localized for a long time at or near its primary site in the pelvis, rarely throws out distant metastases but practically always recurs in the parametrial lymphatics or in the parametrial tissues. It was at once evident that here was a lesion that could be reached by radiation, not only at its primary site but also in the region of the adjoining lymphatics. Soon it was found that carcinoma of the cervix was, furthermore, a disease which, in a large proportion of cases was quite radiosensitive.

Results of radium treatment of cancer of the cervix have shown steady improvement in the last few years, owing to improved irradiation technique. Laborde states that the percentage of cures in cancer of the cervix in the Cancer Institute, University of Paris, is 57.5 per cent for Stage I, 48.9 per cent for Stage II, 31.6 per cent for Stage III, 4.5 per cent for Stage IV; Schmitz reports cures in Stage I of 87.88 per cent, Stage II of 47.17 per cent, Stage III of 17.78 per cent; Healy, Stage I, 58.1 per cent; Stage II, 38.4 per cent; Stage III, 22.0 per cent; Stage IV, 6.3 per cent; Heyman (Radiumhemmet) Stage I, 42.0 per cent; Stage II, 43.0 per cent; Stage III, 17.0 per cent; Stage IV, 9.0 per cent; Miller, Stage I, 50.0 per cent; Stage II, 26.0 per cent; Stage III, 18.0 per cent; Stage IV, 7.0 per cent.

The progress of radiation therapy of the cervix has been slow and orderly, each period has shown an attempt to deliver a maximum amount of radiation to the cancer cells with a minimum effect on normal tissue.

It would be amiss not to point out that a well planned course of radiation therapy demands considerably more painstaking effort in planning of treatment and in preparation of the patient than many major surgical operations. This should be constantly borne in mind if the maximum results are to be expected.

Some therapists employ only radium while others depend largely on roentgen treatments. A study of the methods employed by the most eminent gynecologists makes it clear that adequate irradiation does not mean merely inserting a capsule of radium in the cervical canal for twenty-four or forty-eight hours. In fact, a single capsule of radium rarely has place in the treatment of cancer of the cervix. In all probability, the single capsule is responsible for more deaths from cancer of the cervix than cures. Today the leading cancer therapists and gynecologists are all striving for the same goal and the method of each, while showing slight variation in technique, embodies the principle of administering a lethal dose of radiation to the cervix, parametrium and pelvic glands by means of high voltage roentgen rays delivered to the pelvis and adequately distributed, heavily filtered radium in the uterine canal and vaginal vault.

Radium applied in the uterine and cervical canal, against the cervix and in the vaginal vault, is not effective in destroying cancer cells more than a few centimeters distant from the site of application of the radium. It follows that the primary disease of the cervix can be controlled or cured, but the parametrial disease is not controlled and the retroperitoneal lymphatics are not sufficiently irradiated. This fault in the old treatment prompted Healy to advance the new plan of high voltage roentgen therapy in order to obtain greater intensity of radiation in the pelvis.

There is much misapprehension regarding the use of high voltage roentgen rays in the treatment of cancer of the cervix. From our experience, we are convinced that high voltage roentgen therapy to the cervix and tumor-bearing areas is of paramount importance, and should be the preparation for radium application. This premise is based on our experience; we have observed that

high voltage therapy in individualized doses does prepare the patient for a more suitable radium application. Patients who are badly infected, who present evidences of pelvic cellulitis and other toxic symptoms, are greatly improved, if not completely relieved of the infection by high voltage therapy. The bulky cervical tumor which was present when treatments were started will almost always have melted away by the time the high voltage treatments are terminated, making radium application more facile and and more effective. While it is true that the intensive high voltage plan of treatment carries with it a higher mortality and probably slightly higher morbidity, I believe the method should be continued because of the better end-results. In the more advanced group of patients, Stage IV, with frozen pelvis, etc., we are definitely of the opinion that a moderate amount of roentgen irradiation to the pelvis will make the patient more comfortable and produce better results than intensive therapy; furthermore, we believe that rarely is radium of any value in this group. When the hyperintensive plan of roentgen therapy is used, one should not delay the application of radium more than a week or ten days after the completion of the course of roentgen treatments. It has been observed that a longer delay frequently permits reactivation of residual cancer cells.

For some years past, world-wide attention has been drawn to the method of radium treatment developed by Regaud of the Radium Institute of Paris. This method is based on the purpose of delivering a dose of rays to each generation of cells at that stage of cell division at which the cell is most radiosensitive, and this is accomplished by protracting the delivery of the dose over four to five days. We have used this method with good results.

A plan of irradiation of the para-aortic lymphatics with high voltage roentgen rays, developed by me to be carried out with prophylactic purpose two months after the irradiation of the cervix and pelvis, has already been described.

COMPLICATIONS DURING RADIATION THERAPY

Since the great majority of patients presenting themselves for treatment of cancer of the cervix are in an advanced stage when first seen, certain major complications may be expected to develop during the course of treatment in a rather large number of cases. These patients with advanced lesions are all badly infected before the treatments are started. Douching cannot and does not remove the infection from an advanced cancer of the cervix. Many patients have a mild or severe pelvic cellulitis along with the cervical infection—a natural result. Rest in bed, forced fluids, thorough cleansing of the intestinal tract, and hot saline douches three times a day will do much to combat the infection. When the temperature is running high and there is evidence of grave toxemia, blood transfusions, in small quantities, intravenous glucose, and saline solutions must be added to the armamentarium. Sulfanilamide therapy now in use has saved many a patient with severe infection, and has proved to be a most valuable drug in selected cases. I believe that the best means of controlling infection in cancer of the cervix is roentgen therapy, administered in fractionated doses over a long time. When irradiated in this fashion, one expects to find almost always complete dissolution of the large infected cervical tumor with disappearance of the pelvic inflammation by the time the series of treatments has been completed.

Pyometra following radium therapy should be promptly recognized and gentle dilatation of the cervical canal and drainage of the uterus done. A soft rubber drainage tube should be used whenever needed. When a cul-de-sac abscess has formed, a colpotomy should be done without delay.

Intensive fractional high voltage roentgen treatments over the pelvis frequently give rise to severe skin changes, which if properly cared for are usually not troublesome, but this tendency has forced the radiation therapist to re-educate the re-

ferring physician about skin changes, since the older methods produced very little skin or intestinal upset. Unless this re-education is done, there will certainly be much criticism of the method.

Shortly after the introduction of high voltage roentgen therapy in the treatment of pelvic cancer, we began to see gastrointestinal complications of varying degrees of severity. Martin, many years ago, following his experimental work on dogs, brought forcibly to our attention the changes occurring in the intestinal tract and the danger in high dosage of roentgen rays over the pelvis. Fortunately, the protracted fractional method of delivering doses of roentgen rays to the pelvis has done much to reduce this hazard, yet the danger does occur in a large percentage of cases. Unless the patient is under careful observation, almost certainly the condition will prove disastrous. Just as soon as a patient who is receiving roentgen irradiation over the pelvis develops a loose stool, she should be promptly placed on tr. opium 30 drops every four hours and only liquid nourishment permitted; if the diarrhea is not checked within forty-eight hours, the roentgen treatments must be stopped, and glucose and saline infusions started. Once the diarrhea is checked, the treatments may be resumed. At the present time studies are being carried on with 400 kv. type of roentgen therapy in the hope that irradiation changes produced in the intestinal tract with this technique will be less severe. We hope to be able to report on this at some future date.

The anatomical relation of the bladder and rectum in cancer of the cervix makes it impossible to avoid these structures when radiation treatment is applied. Severe proctitis will be relieved by saline enemas, emptying the large bowel, and then instilling 2 ounces of 2 per cent anesthesene in refined cottonseed oil into the rectum as often as indicated. When the acute symptoms have subsided the patient should be placed on nightly doses of mineral oil to be continued through convalescence. Bladder irritation is best relieved by warm boric acid irrigations and tr. belladonna and hyoscyamus.

When there is severe pelvic pain not relieved by acetylsalicylic acid and codeine, subarachnoid alcohol block should be considered, especially in the more advanced and hopeless cases. The technique of this procedure which is advocated by Stern is simple and safe.

SUMMARY

Seven hundred and twenty-seven cases of carcinoma of the cervix, seen within a period of nearly eight years, are analyzed. In 75 per cent the disease was in an advanced stage.

In treatment a large dependence was placed on intensive, protracted, high voltage roentgen therapy. Less than one-half of the patients received radium therapy in addition.

My method of high voltage roentgen irradiation of the para-aortic lymphatics is described.

Thirty-eight, or 20.10 per cent, of the group of 189 patients treated in 1932, 1933 and 1934 were living on April 30, 1940. Of the 39 patients first seen in 1932, 5, or 12.56 per cent, were alive on the above date; of the 78 patients first seen in 1933, 13, or 16.67 per cent, and of the 72 patients first seen in 1934, 20, or 27.77 per cent, were then living.

Our data do not indicate that educational efforts are succeeding in bringing patients earlier under treatment. It is emphasized that the signs of early cancer are objective, not subjective, and that early diagnosis of cancer of the cervix can be made only on vaginal examination by a physician trained to detect early cancer, aided by histologic study, at a time when the patient has no symptoms of which to complain. Semiannual examination of all women over thirty-five years of age is advocated.*

* For discussion see page 826.

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RESULTS IN TREATMENT OF LYMPH NODE METASTASIS IN CANCER OF THE CERVIX AND THE VULVA*

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WHEN in the fight against cancer, the forces of the enemy have broken through the defense lines of the individual, dashed along the lymph channels and secured a firm foothold within the portals of the tributary lymph nodes, the struggle against them has become more serious but is by no means hopeless. Fortunately in many types of cancer there is still a considerable interval of time between this first break-through to the first chain of lymph nodes and the further spread of the disease to more distant organs. If we limit our attack to the primary site and fail to use every effort to eradicate the disease in these advanced posts, failure to effect a cure is the inevitable outcome. I freely grant that the odds are usually against such an eventual victory in cases of lymph node metastasis, but the policy of despair and mere palliation is not justified by experience. Even though their number may not be very great, cases with lymph node metastasis can be cured for long periods of time, even up to fifteen years or more, as shown in the reports that I shall give.

The main question to be decided is: What agent can best be employed to bring about the destruction of the cancer cells in this new location in the lymph nodes? We have at present only irradiation and surgery as our agents and each has its advantages and drawbacks.

Irradiation whether in the form of radium or deep roentgen therapy has undergone so many changes in technique and apparatus that we cannot at the present time make any positive statements regarding its effectiveness in these cases. All we can say is that, up to this time, relatively little has been accomplished along these lines with radiation treatment. It would seem as if, through some biochemical change, the cancer cell has become more resistant to irradiation when it has passed from the organ where it started to the sheltering protection of the lymph node. Marked regression of tumor nodules may be noted, but their destruction is difficult, if not impossible. In their chapter on "Radio-sensitivity of Tumors" in Pack and Livingston's new handbook on the treatment of cancer, Stewart and Farrow write: "In the tissues examined, great differences are found between the state of the metastatic deposits not only in adjacent nodes but in different areas of the same small node. Complete sclerosis or necrosis and active-looking cancer are found within a few millimeters or even a few micra of one another."

One of the advantages of irradiation over surgery is that its application has a relatively small primary mortality even when employed in the form of the interstitial application of radium needles. On the other hand, we find that in certain areas the tissues will not tolerate an effective cancer-lethal dosage. Pack and Wuester state: "The delicate moist skin of the axilla and groin tolerates radiation poorly and limits the total dosage that can safely be given."

Surgery also has certain points in its favor and against it. When we have surgically excised a lymph node, we need not fear, as in the case of radiation therapy, that a small nest of cells which has escaped eradication by gamma rays will at some later period multiply and overwhelm the patient. An irradiated metastatic lymph node is always an uncertain quantity. On the other hand, we know the complete anatomical resection of the entire tributary lymph chain is both difficult and attended by a certain unavoidable primary mortality. In the days before irradiation many radical lymph node resections were done, with a

* Read at the Twenty-fifth Annual Meeting, American Radium Society, New York, N. Y., June 10–11, 1940.

FIG. 1. Large cancer metastasis in left hypogastric lymph node removed by iliac lymphadenectomy on October 14, 1930. This patient is still well and free of recurrence nine and a half years later.

high primary operative mortality. These have in many instances been either abandoned or modified. An operative mortality over 10 per cent will only in certain limited types of cancer be justified. We have, however, found ways of decreasing the primary death rate in many of our operative procedures, so that the risk has been reduced to a point that does not contraindicate surgical intervention.

In the more superficially situated lymph node chains as the axilla, the groin and the neck, the employment of satisfactory crossfire methods of irradiation is limited and the chance for skin necrosis when large amounts are used, are definitely increased. In the pelvic lymph nodes, their sheltered location close to the larger bones makes radiation treatment more difficult. Regaud found that in early cancer of the uterine cervix failures of treatment by irradiation methods were usually due to recurrence in the pelvic lymph nodes.

While surgery is thus preferable to irradiation in the treatment of lymph node involvement, we should, I believe, differentiate in accordance with the site of the primary tumor. Thus in cancer of the uterine corpus, in which lymph node metastasis is relatively infrequent and the tributary lymph channels following the course of the ovarian vessels lead to the glands around the aortic bifurcation and higher, a surgical enucleation would certainly not be justified. In the present paper I shall consider only two types of carcinoma in both of which lymphadenectomy is, I believe, justified; that of the uterine cervix and that of the vulva. My experience with radical lymph node resections in these two groups has been rather extensive and the interval of time that has elapsed has been sufficient to justify tentative conclusions as to the five year cures obtained by such a surgical lymph node enucleation.

Cancer of the Cervix. Experimentally, at the onset of developing the operation of iliac lymphadenectomy, I attempted the procedure in 8 cases of Group III cancers with involvement to the pelvic wall. Three of these patients died of infection postoperatively. Hence I discarded the operation for this group and do not include them in my series. I have since then limited the procedure to Group II cases, those with definite parametrial involvement or extension to upper vagina or uterine body. A total of 136 such operations has now been done since October, 1930, with a primary mortality in but 2 cases, or 1.47 per cent. In the early cases the operation was done simultaneously with the radium treatment, and it was in this first group of 34 cases that the two operative deaths occurred. In the last 102 iliac lymphadenectomies there has not been a single operative death. While there is, of course, an element of good fortune in such a record, it demonstrates beyond any reasonable doubt that this operative procedure carries with it no appreciable risk.

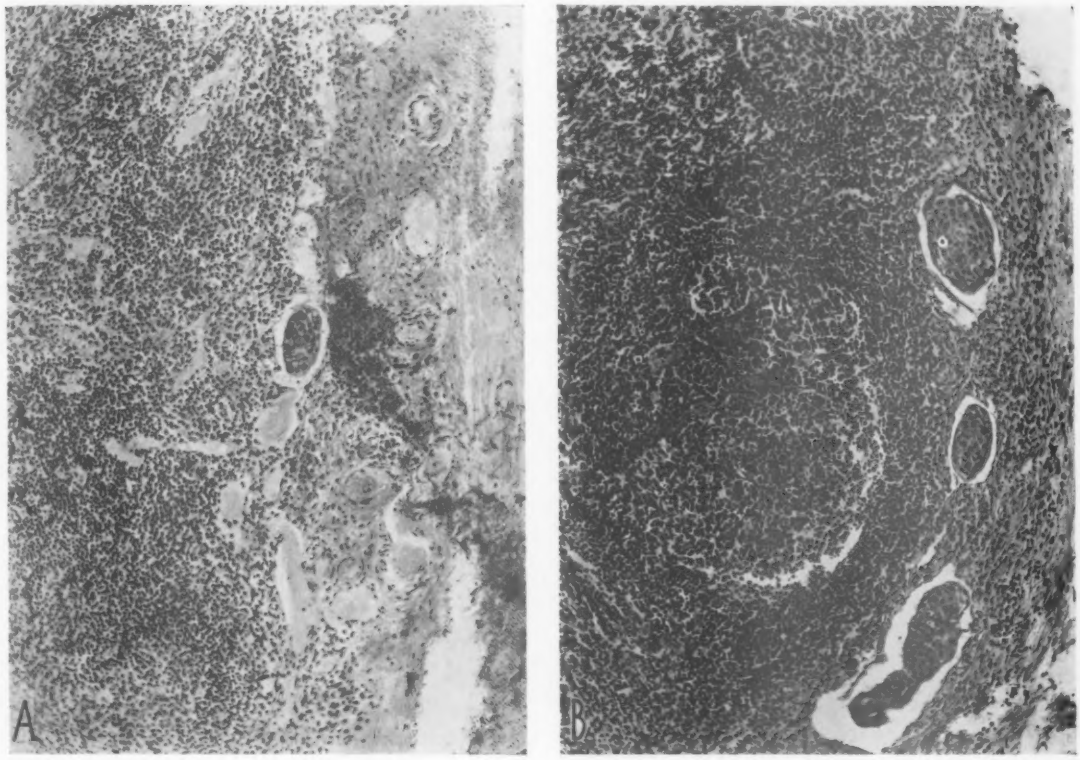

Fig. 2. *A*, minute microscopic subcapsular cancer metastasis in right hypogastric lymph gland; *B*, slightly larger metastasis in the left hypogastric lymph node of the same case.

Since the last report a year ago 11 more cases have passed the five year limit. The total of 30 cases show a five year survival of 14, or 46.6 per cent, as compared with the 52.5 per cent obtained in the 19 cases previously reported. During this period the radiation treatment, especially the roentgen therapy, was relatively ineffective. It averaged between 2,500–3,000 r as compared with four times that amount employed at the present time. The important thing to bear in mind is that compared with similar cases treated by irradiation alone during this period, the five year survival rate was twice as great when the tributary lymph nodes were removed. Of these 30 cases operated on over five years ago, 12, or 40 per cent, showed evidence of cancer metastasis. Three of these 12 survived the five years and an additional one lived for four years ten months. The 25 per cent five year survival with metastatic lymph nodes should be compared with 11 survivals out of 18, or 61 per cent, in cases without metastasis.

Of the 3 five year survivals with metastatic lymph nodes, the most striking case was the very first one operated on in October, 1930. Almost ten years have now elapsed: the patient is free of recurrence, although at operation the left hypogastric lymph node was full of cancer, enlarged to the size of a walnut (Fig. 1).

It is reasonable to assume that in a not inconsiderable number of cases, minute metastases are overlooked. Evidence supporting this contention came in a case operated on last November in which two small, apparently normal hypogastric nodes showed a subcapsular metastasis only a few micra in thickness (Fig. 2) that would have been missed if the sections had been taken at a slightly lower level. It is also possible that the intensive preoperative roentgen irradiation now employed makes it more

TABLE I

	Cases	Survived Number	Survived Per cent
Double-sided Basset with vulvectomy	41	24	58.5
Superficial or one-sided gland removal with vulvectomy	21	6	28.6
Vulvectomy only	12	1	8.2
Radiation treatment (mostly advanced cases)	21	1	4.8
Palliative measures	6	0	0
Total	101	32	32

difficult to recognize smaller metastatic nests.

Several large clinics have recently taken up the operation of iliac lymphadenectomy, and when this additional clinical material has been studied for the required period of time we shall at last be able to define more accurately the benefits of this procedure. In the meantime I can say with reasonable assurance that I have done these patients no appreciable harm by this operation, that some good has been accomplished, but how much this may be, will depend on the wider experiences of many cancer clinics.

Cancer of the Vulva. I feel far more certain of my ground in discussing the results of lymph node resections for cancer of the vulva. A fairly large material has come under my observation in the past thirty years at the Barnard Free Skin and Cancer Hospital and in private practice. This series of 155 cases from 1911 to 1940 showed that in 95 instances a partial or complete inguinal lymph node removal was done in combination with the surgical excision of the vulvar tumor. In 46 of these 95 cases, or 48.5 per cent, cancer metastasis was found in the lymph nodes of one or both sides. The 27 cases in which only a superficial or unilateral lymph node removal was done are of interest primarily because of the fact that in only 6 instances was a five year survival obtained. This 28.6 per cent survival rate is only slightly better than the 15–20 per cent reported by various writers with radiation treatment (radium to the vulva and deep roentgen treatment to the inguinal nodes). That the double-sided Basset operation with vulvectomy gives by far the best results is evident from Table 1 analyzing 101 cases in my series observed for longer than five years.

TABLE II

	Number	Survived 5 Years	Per Cent Survived
Group I (lesions 1–3 cm. in diameter)	10	10	100
Group II (lesions 4–7 cm. in diameter)	20	9	45
Group III (lesions over 7 cm. in diameter)	10	5	50
Group IV (fixed metastatic lymph nodes)	1	0	0
Total	41	24	58.5

TABLE III

	Number	Five year Survivals	Per Cent Survivals
Lymph node metastasis present	19	10	52.6
Lymph node metastasis absent	22	14	63.6

A more detailed analysis of the 41 cases of complete Basset operations done over five years ago show some interesting facts. With only one exception these cases were all definitely in the operable groups without large adherent metastatic glands or extension of the disease up the vagina. Many of them, however, were large tumors over 7 cm. in diameter with definite metastatic lymph nodes. Table II shows the final outcome in these cases.

It is worthy of special note that all of the 10 early cases of cancer of the vulva survived for five years or longer without any evidence of recurrence. One of the

Group II cases could not be traced. The remaining 40 cases were all followed up.

Lymph node metastasis was present in 19 of the 42 cases, or 45 per cent. It is interesting that the presence of such a metastasis has in my series been of less consequence than the increased size of the primary lesion. It was found that the metastatic cases were only 11 per cent less frequently cured, whereas the lesions 4 cm. or larger showed 50 per cent fewer five year survivals than the early small lesions. Table III gives the figures.

When we analyze the ten year survivals after the Basset operation, the figures are of course smaller. There were 24 such cases and 16 of them survived over five years. Ten survived the ten year period (41 per cent). Two of the 6 who died in this interval showed no evidence of a recurrence of the primary disease. Again we note that the presence of a lymph node metastasis has had no marked influence on the survival rate, for 4 of the 10 cases that survived the ten year period showed such a metastasis. One of these 4 patients with metastasis is living and well sixteen years after operation and another died of senility at eighty-three years of age after twelve years' freedom from recurrence.

The following 3 case histories are illustrative of some of the points that have been brought out.

Case I. Miss G., aged sixty-two, had an artificial menopause at the age of thirty-five due to removal of both ovaries. In June, 1934, she noticed a burning in the left side of the vulva associated with a bloody discharge. Two months later a kernel was felt in the left groin. By September there was discomfort on sitting down. She consulted a physician in November, who found a vulvar tumor with metastasis and referred her to me. I found an ovoid tumor 7 cm. in diameter located beneath the skin in the region of the left Bartholin gland with an area of ulceration 1 cm. in size in the vestibular region. In the left groin a hard movable nodule 3 cm. in diameter could be felt together with several smaller nodes on that side and in the right inguinofemoral region. Operation on December 12, 1934, consisted of a diathermy excision of the tumor and vulvar skin together with a double-sided Basset operation. The postoperative course was unusually smooth. Microscopic examination of the lymph nodes showed not only metastasis in three of the femoral lymph nodes on the right and the left side but also an involvement of the external iliac lymph node and the obturator lymph node on the left side (Fig. 3). These two nodes lay beneath the peritoneum of the abdominal cavity to either side of the external iliac vessels. I have heard from her at regular intervals and her physician, Dr. Willits of Grand Rapids, Michigan, has examined her and found her clinically well. Five and a half years have now elapsed since the operation.

Fig. 3. Lymph node metastasis in the left obturator region in a case of Bartholin gland carcinoma. Although five lymph nodes in both inguinal regions showed metastasis, this case has remained well and free of recurrence over five years.

Case II. Mrs. M., aged sixty-eight, 3 children, first consulted me on January 24, 1928, with a history of soreness about the external genitals for a year or two. For three months there was pruritus and a blood-tinged discharge. Examination showed a superficial cancer the

size of a silver dollar over the left labial and preputial region with an atrophic leukoplakic vulvitis over the remaining vulvar skin. All operative measures were refused at this time. Hence a surface application of 100 mg. of radium was made for eighteen hours and four radium seeds totalling 1,000 mc-hr. were inserted in the peri-urethral area: total dosage, 2,800 mg-hr. The tumor melted away leaving painful burns. In September of the same year hard enlarged nodes were noted in both inguinal regions. On October 5 the patient consented to the surgical removal of these nodes. The age of the patient and a blood pressure of 185/85 made an extensive operation inadvisable. The nodes on both sides showed large metastases. The following year, owing to repeated radium necrosis over the irradiated area, a surgical excision of this portion of the vulva was done. There was no further trouble and examination on January 27, 1939, showed no evidence of recurrence. The latest report in December, 1939, stated that she was entirely well, over eleven years after removal of the cancerous lymph nodes.

CASE III. Mrs. C. C., aged sixty-five, was referred to me on January 29, 1924, by Dr. Morris of Decatur, Illinois, for a recurrent carcinoma of the vulva, which he had previously excised and then applied radium. The recurrent lesion was only 2 cm. in diameter situated in the right labia on a basis of typical leukokraurosis of the vulva. A vulvectomy was done January 31 and the double-sided Basset operation February 16, 1924. One of the femoral lymph nodes on the left side showed a cancer metastasis. The primary tumor was of very low grade malignancy. A small vulvar keratosis was removed December 2, 1925, but no cancer found. She has come to see me every six months; the last time in April, 1940, and has had no evidence of recurrence for over sixteen years.

CONCLUSIONS

Lymph node metastasis in cases of cervical cancer and in cancer of the vulva by no means justifies the conclusion that a five year or even a ten year cure is impossible. This can almost never be accomplished by irradiation, but by surgical ablation of the immediate tributary chain of lymph nodes freedom from recurrence can be attained in a considerable number of patients. In cervical cancer the presence of a lymph node metastasis reduces the cure to one-half that of the cases without metastasis. In cancer of the vulva, however, if the complete Basset operation is done, the difference bebetween metastatic and non-metastatic cases is only 11 per cent (52.6 per cent compared to 63.6 per cent). The operative mortality in both groups is so small that it is no appreciable factor in the final results obtained.*

* For discussion see page 826.

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CARCINOMA OF THE CERVIX UTERI IN CHILDHOOD AND ADOLESCENCE

A REVIEW OF THE LITERATURE AND REPORT OF AN ADDITIONAL INSTANCE OF THE LESION IN A GIRL AGED THIRTEEN*

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ALTHOUGH carcinoma of the cervix uteri among patients between the ages of twenty and thirty is not at all uncommon, it is rarely found in younger patients. Because of the rarity of the disease among patients twenty years of age or younger, the difficulties usually encountered in making the diagnosis, and the emphasis placed on the so-called cancer age, the diagnosis of this condition among young women is frequently confused or missed entirely. The necessity of making a careful manual and visual examination, as well as histopathologic examination of any tissue which may be at all suspicious, cannot be overemphasized, as the case presented herewith clearly demonstrates.

A review of 3,000 patients suffering from malignant disease of the cervix uteri who had been referred to The Mayo Clinic for examination and treatment revealed only one patient twenty years of age or younger. The following is a summary of the history of this patient.

REPORT OF A CASE

The patient was a well-developed, unmarried, white girl thirteen years of age. She had suffered from the more common diseases of childhood, but had had no illness of any particular significance. The history of this patient's family, also, was not significant. She had been perfectly well until about the last week of February, 1934, at which time she began to complain of severe, intermittent pain in the region of the coccyx. This pain was present whether or not she was sitting or standing, and there was no history of injury. Her menstrual periods had commenced about six months previous to the onset of her illness, and had occurred at intervals of thirty days, and had lasted for three or four days without causing her any discomfort. On March 7, 1934, she had had a sudden and profuse vaginal hemorrhage of bright red blood in which a small piece of tissue was extruded. The bleeding had continued for two days, at the end of which time the patient had consulted her local physician. At his examination, what appeared to be a polyp protruding from the cervical canal was removed, and the base was destroyed thoroughly with electrocautery. The specimen was removed in pieces and measured, collectively, about 2.5 by 2 by 1 cm. This tissue was examined microscopically elsewhere and was reported as showing evidence of a malignant tumor containing large hyperchromatic and multinucleated cells suggestive of an embryonic carcinoma, although some portions of it were suggestive of hypernephroma. The patient was then referred to The Mayo Clinic for further investigation and treatment, with the thought that total abdominal hysterectomy might be done.

General examination of this patient at The Clinic on March 29, 1934, revealed nothing significant. The patient's height was 61½ inches (155 cm.), her weight was 110 pounds (50 kg.), and there had been no loss of weight. The systolic blood pressure was 123 and the diastolic pressure was 73, expressed in millimeters of mercury. The value for hemoglobin was 13.9 gm. per 100 cc., the erythrocyte count was 4,560,000 and the leukocyte count was 14,300. Reaction of the Wassermann test of the blood was negative. The sedimentation rate was 15 mm. per hour. Examination of the urine disclosed nothing abnormal. The Aschheim-Zon-

* Read at the Twenty-fifth Annual Meeting, American Radium Society, New York, N. Y., June 10–11, 1940.

dek test and also the Mantoux test gave negative results. A roentgenogram of the thorax revealed nothing abnormal. On March 30, 1934, the pelvic region was examined while the patient was under the influence of general anesthesia, and thorough curettage of the uterus was done. No gross evidence of malignant disease was apparent, by either direct observation or palpation. The tissue removed by curettage was examined histopathologically by Dr. Broders, and was reported as being normal endometrial tissue. In view of this, the surgeon did not feel justified in performing hysterectomy, and the patient was returned to her room for further study. Dr. Broders then reviewed the sections of the tissue which had been removed by the referring physician, and reported them as being a Grade 4 carcinoma, probably adenocarcinoma. It became apparent, then, that there must have been a source of the malignant tissue which had not been determined during the curettage of the uterus, and on April 2, 1934, seven specimens for biopsy were removed from various portions of the cervix, and were examined histopathologically. Two of these specimens were reported as being Grade 4 adenocarcinoma.

It was concluded on the basis of these studies that the lesion must be extremely limited in extent, and the surgeon still did not think that hysterectomy was indicated. The patient was then referred to the Section on Radium Therapy for consideration of treatment, where the lesion was classified as being in the Stage 1 modified group.* It was concluded that, since the surgeon did not feel justified in removing the uterus, and since the lesion was evidently limited in extent and was of a high grade, and because of the previous surgical intervention and cauterization, radium therapy should not be so intensive as to destroy the reproductive function of the genital organs. Therefore, a cautious treatment with radium was outlined to take the form of the universal tube of radon applied to the cervical canal alone for short periods. On April 5 the patient received a treatment of 42 millicuries for eight hours, or 336 millicurie-hours. On April 9 she received a second treatment of 34 mc. for ten hours, or 340 mc-hr. The radon capsules were placed in the anterior region of the cervical canal treating a depth of 2.5 cm. in both applications. The filtration of the capsules was 0.5 mm. silver and 1 mm. brass. No further radiation treatment was administered, the total dose being 676 mc-hr. No apparent systemic effect resulted from the irradiation.

The patient began to menstruate again two months later, in June, 1934. In August, 1935, the menstrual periods became somewhat irregular, occurring at eighteen to forty day intervals and being accompanied by occasional cramps just before the flow. In February, 1936, the patient had slight intermenstrual bleeding for four days which occurred only during urination and which did not necessitate her wearing a sanitary napkin. Dilatation and curettage were performed by her home physician at this time, but no gross or microscopic evidence of malignant disease was found. Following this procedure there was a period of amenorrhea three months in duration. The patient was last examined at The Clinic in August, 1938, at which time she was in excellent health. Her menstrual periods occurred regularly every twenty-eight days and lasted three or four days with normal flow and no discomfort. At the time of this writing, more than six years from the time of the initial treatment, the patient is well, menstruation is normal and she is apparently free of malignant disease.

A careful search of the literature since 1862 revealed the reports of only 25 cases of carcinoma of the uterine cervix in which the patients were girls twenty years of age or younger. Some of these cases appear to be of doubtful authenticity, and in many of them there is no record that a histologic examination was made to corroborate the clinical diagnosis.

RÉSUMÉ OF REPORTED CASES

Glatter, in 1870, as cited by Engelhorn, mentioned that in Vienna between the years 1862 and 1869 there were 2 instances of carcinoma of the uterus among young women, and both of the patients died. One was a woman seventeen years old, and the other was a woman nineteen years old. No additional details were given. Engelhorn considered that in the aforementioned two reports insufficient evidence was present for the lesions to be classified as true carcinoma of the cervix. Engelhorn also mentioned Schauta's case of malignant adenoma of the cervix in which the patient was a girl seventeen years of age.

Beigel, in 1875, as quoted by Baldwin, stated that

* Clinically the original malignant lesion was limited to the cervix uteri and since the gross appearance had been greatly altered by previous surgical procedures, the lesion was accordingly classified as Stage 1, modified.

he had seen one instance of uterine carcinoma in a girl nineteen years old, but he did not state whether or not the tumor arose in the fundus or in the cervix uteri. No additional details were given.

In Rosenstein's case, reported in 1883, the lesion occurred in a child two years old. The report of this case stated that the preparation of the specimen did not permit of a definite diagnosis, but that the lesion probably was a carcinoma of the cervix.

Eckhardt, in 1887, reported Frankel's case in which carcinoma of the cervix afflicted a young woman nineteen years old. The tumor presented on a pedicle from the cervical canal, and was stated to have been the size of a child's head.

Ganghofner, in 1888, reported a case in which carcinoma of the cervix occurred in a child eight years old. The diagnosis in this case has been questioned by other authors, but the specimen was reviewed by Professor Chiari of Prague, who confirmed the diagnosis. It was probably a genuine instance of carcinoma of the cervix.

Little, in 1896, reported a case in which carcinoma of the cervix afflicted a girl fourteen years old. Unfortunately, the clinical diagnosis was not confirmed by histologic examination; however, it was probably a true instance of carcinoma of the cervix. The lesion was found to be inoperable, and the patient died.

Tschop, in 1897, reported a case in which carcinoma of the uterine cervix afflicted a girl nineteen years old. The diagnosis was confirmed by histologic examination, but the report of this examination was not presented. Hysterectomy was performed and the patient apparently recovered.

Boyd, in 1905, reported a case in which a lesion that afflicted a girl eighteen years of age was described as being either an adenocarcinoma or an endothelioma of the cervix. The Pathologic Committee of the London Obstetrical Society, to which the specimen was submitted for examination, reported that portions of the tumor resembled ordinary papillary adenocarcinoma, whereas other portions suggested that the growth originated in the endothelium of the blood vessels. Hysterectomy was performed, and the patient apparently was in good health one year later.

Webster, as cited by Bonner, presented Gusserow's statistics concerning 3,471 cases of carcinoma of the cervix, in which 2 of the tumors occurred when the patients were less than twenty years old. These are the 2 cases mentioned by Glatter and Beigel. Bonner also quoted Koblanck, who reported that in a larger series numbering 6,364 cases of carcinoma of the cervix, he found only the 2 cases mentioned by Gusserow in which the patients were less than twenty years old.

Bumm, in 1908, reported a case in which adenocarcinoma occurred in a child eight months old. The lesion extended along the anterior uterine wall and involved part of the cervical lip. It is questionable whether this was a primary carcinoma of the cervix. The histologic diagnosis was confirmed by Aschheim.

Glöckner, in 1908, reported a case in which carcinoma of the cervix afflicted a child seven years old. The diagnosis of adenocarcinoma was confirmed by Robert Meyer and Carl Ruge. Panhysterectomy was performed, and the child lived for four years before inguinal metastases developed. In this case the lesion affected the youngest patient on record as suffering from authenticated carcinoma of the cervix.

De Rouville, in 1912, reported a case in which carcinoma of the cervix occurred in a patient eighteen years old.

Cragin, in 1913, reported a case in which carcinoma of the cervix afflicted a patient eighteen years old. The diagnosis in this case was confirmed histologically by Francis Carter Wood.

Wells' case, reported in 1913, of adenocarcinoma of the uterus in which the tumor was situated at the level of the internal os in a woman eighteen years old, was mentioned by Peterson in his review of 500 cases of uterine carcinoma. This patient underwent radical vaginal hysterectomy, and was reported to be in good health four years later.

Adams, in 1916, reported an instance of adenocarcinoma of the cervix in a child two and a half years old. The Pathologic Committee of the Royal Society of Medicine, however, reporting on the specimen, called the tumor a "teratoma."

Neill, writing in 1936, referred to his report of carcinoma of the cervix in a woman sixteen years of age which appeared in the *Western Medical Times* of December, 1920.

Darnall, in 1921, reported on an adenocarcinoma of the cervix occurring in a Negress twenty years of age. The Negress was unmarried, and gave no history of pregnancy or miscarriage. Following panhysterectomy, the patient died of pulmonary embolism.

Lisa and Cornwall, in 1926, reported a case in which squamous cell carcinoma of the cervix afflicted a girl sixteen years of age. There were metastases to the lungs, liver, heart and spleen. Exploratory laparotomy was performed, and death occurred some time later.

Bonner, in 1927, reviewed the literature and added a case of his own in which the lesion occurred in a thirteen year old Jewess. The patient had begun to menstruate at the age of eleven years, and had always experienced menstrual irregularity of some extent. About a year later a thick, creamy, foul vaginal discharge developed, which was followed shortly by a profuse vaginal hemorrhage, which was repeated on several occasions. The patient then received two deep roentgen-ray treatments over the spleen and flat bones, which did not influence the course of the bleeding. She was then admitted to a hospital where she received a transfusion of blood. A vaginal examination was apparently not done, and she was discharged with a diagnosis of "ovarian dyscrasia." The patient then came under Bonner's care, and an examination revealed a soft, rounded mass the size

of an orange replacing the cervix and filling the entire vaginal vault. The growth appeared as a pale, cauliflower type of tumor, giving the impression of being a degenerating polyp, and presenting an ulcer 1 cm. in diameter. The vaginal wall at the vault was slightly indurated. The uterus was not definitely outlined. and no masses were felt abdominally. Removal by cautery of the entire infra-vaginal portion of the cervix was done, and five radon seeds of 0.5 mc. each were inserted into the stump. The uterine cavity was treated with 25 mc. of radon for forty-five hours. The histologic diagnosis of adenocarcinoma was made by Dr. Lederer, and was corroborated by Dr. E. S. l'Esperance and Dr. James Ewing. The patient apparently was in good health nineteen months after treatment.

Baldwin reviewed 905 cases of carcinoma of the uterus, vagina and vulva, but did not find any instances of carcinoma of the cervix among women less than twenty years old. He referred to MacDonald's case, which was reported in 1929. The lesion occurred in a child ten years old, and was an adenocarcinoma of the cervix. The patient had been treated for some time in the belief that she was suffering from gonorrheal vaginitis before the true nature of the condition was discovered.

Morse, in 1930, reviewed the literature on carcinoma of the female genital tract in childhood, and reported a case in which carcinoma of the cervix occurred in a child ten years old. The patient came to his attention some two years after a diagnosis of gonorrheal vaginitis had been made on the basis of smears taken from the vagina. Prolonged treatment for this condition by means of douches had proved ineffectual. Examination revealed tenderness in the suprapubic region, but no palpable pelvic mass. Vaginal examination by means of a speculum provoked sharp bleeding, and digital examination revealed a mass on the cervix. Histopathologic study of the tissue removed showed it to be an epithelioma. Laparotomy was performed with the intent of removing at least part of the mass; however, it was found impossible to accomplish this and the abdomen was closed with the objective of instituting deep roentgen therapy at some later date. This was not done, and the patient died suddenly about eleven months after coming under observation. Necropsy was not permitted.

Ludwig, in 1936, reported a case in which a sixteen year old girl had carcinoma of the cervix. The patient had had a brownish, sanguineous discharge for about six months, with slight pain in the lower portion of the abdomen and pelvis, and a burning sensation in the vagina. Palpation revealed tenderness just above the pubes, but no mass was demonstrable. Several small pieces of tissue were obtained at vaginal examination and were reported to be adenocarcinoma. Examination with the patient under anesthesia revealed a soft, friable mass which filled the upper half of the vagina, and which involved the entire circumference of the cervix. The uterus was slightly enlarged. Dilatation and curettage were done, but no uterine tissue was obtained. Three pieces of tissue were obtained from the cervical mass, and the remainder of the cervix was amputated by cautery. The aforementioned three specimens were also diagnosed as being adenocarcinoma. The patient received a radium treatment at this time of 3,160 mg-hr., the details of which were not given, and roentgen therapy was started three weeks later. Five months later the patient received an additional radium treatment of 1,425 mg-hr. No details of this treatment were given. The menstrual flow recommenced slightly more than three years after the first treatment by irradiation, and the patient was reported to be in apparent good health slightly more than five years from the time treatment was first instituted.

Puccioni, in 1937, discussed carcinoma of the cervix uteri in young women. He stated that West in 1864 was the first to report carcinoma of the uterus in young women. He referred to a case in which carcinoma of the cervix afflicted a woman seventeen years old; this case had been reported by Spiegelberg in 1872. No details regarding the case were given.

Smythe, in 1937, mentioned one instance of carcinoma of the cervix in a girl nineteen years old in a group of 357 cases. He furnished no particulars concerning the case.

COMMENT

The available literature and reports of cases reviewed for this study may be considered limited and additional important data concerning the essential particulars were not completely recorded. Our comments also will be limited.

The incidence of carcinoma of the cervix uteri among children and adolescent persons is very low. The low incidence of carcinoma of the cervix uteri occurring among nulliparous patients also is of interest in our study. Hammond stated that "it would be safe to say about 3 to 4 per cent of the cases of carcinoma uteri occur in nulliparous women." In the series of cases of carcinoma of the cervix reported by one of us (Bowing), the influence of sterility and fertility was studied. "There were, 1,473 (98.8 per cent) married patients and eighteen (1.2 per cent) single patients. One or more preganancies occurred in each of 1,320 patients, an incidence of 88.5 per cent. According to the records of 149 patients (10 per cent), pregnancy did not

TABLE I

BRIEF SUMMARY OF 25 CASES OF CARCINOMA OF THE CERVIX UTERI RECORDED IN THE LITERATURE, AND 1 CASE ADDED BY THE AUTHORS

No.	Age of Patient, years	Author	Authenticity	Pathologic Process
1	17	Glatter	Doubtful	Unknown
2	19	Glatter	Doubtful	Unknown
3	17	Schauta (Engelhorn)	Probable	Unknown
4	19	Beigel	Doubtful	Unknown
5	2	Rosenstein	Doubtful	Carcinosarcoma
6	19	Frankel (Eckhardt)	Probable	Unknown
7	8	Ganghofner	Probable	Unknown
8	14	Little	Probable	Unknown
9	19	Tschop	Proved	Unknown
10	18	Boyd	Proved	Adenocarcinoma
11	8 mo.	Bumm	Doubtful	Adenocarcinoma
12	7	Glöckner	Proved	Adenocarcinoma
13	18	de Rouville	Probable	Unknown
14	18	Cragin	Proved	Unknown
15	18	Wells	Proved	Adenocarcinoma
16	2½	Adams	Doubtful	Adenocarcinoma
17	16	Neill	Probable	Unknown
18	20	Darnall	Proved	Adenocarcinoma
19	16	Lisa and Cornwall	Proved	Squamous cell carcinoma
20	13	Bonner	Proved	Adenocarcinoma
21	10	MacDonald (Baldwin)	Proved	Adenocarcinoma
22	10	Morse	Proved	Squamous cell carcinoma
23	16	Ludwig	Proved	Adenocarcinoma
24	17	Spiegelberg (Puccioni)	Doubtful	Unknown
25	19	Smythe	Probable	Unknown
26	13	Bowing and McCullough	Proved	Adenocarcinoma

Total proved cases, 12. Total probably authentic, 19. Adenocarcinoma, 10 (not including Bumm's case). Squamous cell carcinoma, 2. Carcinosarcoma, 1. Youngest patient in proved case, 7 years.

occur." In twenty-two records (1.5 per cent), the incidence of gravidity was not stated. Hammond quoted Kelly: "In advance of the local examination the fact that the patient is a nullipara is always strong presumptive proof against cancer of the cervix uteri." In the light of these considerations, the clinical diagnosis of the condition discussed herein evidently is decidedly tedious, especially when it is considered that carcinoma is not ordinarily included in the differential diagnosis among patients so young, as well as nulliparous women.

The recorded data would not permit of an estimate of the stage of involvement found. This is a very important determination, in that the diagnosis, treatment and prognosis are dependent on this essential feature in an instance of carcinoma of the cervix uteri.

A brief summary of the cases reviewed herein, concerning the author, age, pathologic process and authenticity, are contained in Table 1. Twelve cases were considered proved and 19 probably were authentic. Histopathologically proved instances are as follows: 10 cases reported as adenocarcinoma, 2 cases of squamous cell carcinoma and one case of carcinosarcoma. The youngest patient who had proved car-

TABLE II

TABULATION OF THE HISTOPATHOLOGIC ASPECTS, TREATMENT AND SURVIVALS IN 6 CASES REPORTED IN THE LITERATURE REVIEWED FOR PRESENT STUDY IN WHICH PATIENTS SURVIVED ONE YEAR OR MORE

Cases	Histopathologic Observations	Surgical	Radium Treatment	Roentgen Treatment	Survivals 1 yr. and more
Bonner No. 3	Adenocarcinoma	Cautery removal of portio vaginalis	5 radon seeds 0.5 mc. each placed in stump of cervix	None	In good health 19 mo. and more
Ludwig No. 16	Adenocarcinoma	Dilatation, curettage, cautery removal of cervix	3160 mg-hr. radium	Roentgen therapy 3 weeks later	Menses began 3 yr. later
			5 mo. later 1,425 mg-hr.	None	Well 5 yr. and more
Tschop No. 26	Carcinoma	Hysterectomy	None	None	Apparently recovered
Boyd No. 5	Papillary adenocarcinoma	Hysterectomy	None	None	Well 1 yr. later
Glöckner No. 12	Adenocarcinoma	Panhysterectomy	None	None	Lived 4 yr. Metastasis developed to inguinal nodes
Wells No. 27	Adenocarcinoma	Radical vaginal hysterectomy	None	None	Well 4 yr.

cinoma of the cervix uteri was seven years of age.

Data concerning the treatment and results also were incompletely recorded. There were 6 cases in which survival for one year and more was stated, and for these 6 cases a brief presentation of the histopathologic aspects of the tumors, treatment and results of treatment appears in Table II.

Results of histopathologic diagnosis were positive in all 6 cases. Some type of surgical intervention was the initial treatment employed. Hysterectomy was done in 2 cases; panhysterectomy and radical vaginal hysterectomy in one case each. Dilatation and curettage with removal by cautery of the cervix was done in one case and in one case the patient was recorded as having undergone removal by cautery of the portio vaginalis.

In Ludwig's case, a patient sixteen years old survived five years and more. Following dilatation, curettage and removal by cautery of the cervix, 3,160 mg-hr. of radium was applied and three weeks later roentgen therapy was given. Five months later a second application of 1,425 mg-hr. of radium was given. It is of interest to notice that the menses reappeared three years later.

In Wells' case a patient eighteen years old survived four years and probably more. The only procedure employed was radical vaginal hysterectomy.

In Glöckner's case, a patient seven years old, the youngest patient recorded, survived four years. Panhysterectomy was the only procedure employed for her.

Morton cited Neill's statement that the prognosis in young patients is particularly bad, and emphasized the need for careful examination by the physician of every patient.

SUMMARY AND CONCLUSIONS

In a recent review of 1,491 cases of carcinoma of the cervix, Fricke and one of us (H.H.B.) have shown that it is essentially

a disease of older women, the average age of the patients being forty-nine years. This incidence does not mean that carcinoma of the cervix does not occur at a younger age, however, as our single case strikingly demonstrates. It is further shown in the aforementioned review that epitheliomas are found much more frequently than the glandular type of carcinoma. Thus, in 1,491 cases, epitheliomas occurred in 93.5 per cent. However, among younger groups of patients a predominance of epitheliomas does not seem to be the rule, since of the 12 cases reported in the literature in which a histopathologic examination was made, the lesion in only 2 proved to be epithelioma, whereas in 10 the lesion was adenocarcinoma.

The case we have presented is unusual in that the tumor was a Stage 1 modified lesion, whereas in the large majority of cases of carcinoma of the cervix the lesions are in the inoperable stage when the patients are first seen. The response of the patient in our case to radiotherapy corresponded to that of the patients who had modified Stage 1 lesions as reported in the larger group of cases, since all the patients in this latter group were alive five years or more after treatment.

The need for individualization in the management of such patients will be apparent from the report presented concerning our patient. In addition, the need for the closest cooperation among the radiologist, pathologist and surgeon is further emphasized. The physician or surgeon should not exclude the possibility of the presence of carcinoma because of the age of the patient. In all cases a vaginal and rectal examination, including palpation and inspection should be made, and multiple biopsies may be necessary if there is the slightest question about the diagnosis.

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DISCUSSION OF PAPERS BY MURPHY AND HUFFORD; EDWARDS; TAUSSIG, AND BOWING AND MCCULLOUGH

DR. MAURICE LENZ, New York. It has long been realized that when cancer of the cervix has extended into the parametria or lower lumbar lymph nodes, treatment with intracervical and intravaginal radium applicators is inadequate. External irradiation with roentgen rays has therefore usually been added in such cases. At times it proved difficult to deliver adequate amounts of 200 kv. roentgen rays to some of these deeply situated cancerous foci. For instance, Baclesse of the Radium Institute of Paris, found that he could not control the disease in any patient weighing more than 147 pounds in a series of 63 patients with advanced cancer of the cervix treated only by 200 kv. roentgen therapy. In view of this need for increased depth dose, it was logical to apply higher voltages to this problem as soon as suitable apparatus became available. Benefit could be expected chiefly in cases showing extension into the parametria. Accordingly, Henry and Herbert Schmitz and Sheehan investigated the percentage of three and four year clinical arrests in a group of cases of carcinoma of the cervix, chiefly with parametrial involvement. They found the proportion increased from 29 per cent to 50 per cent when they raised the voltage from 200 kv. to 800 kv. Now Murphy and Hufford have shown their interesting results with 400 kv. They call special attention to the relatively slighter skin effect and lesser radiation sickness. Just as with roentgen therapy at 200 kv., however, the reaction of the radiosensitive colon and rectum, as manifested by diarrhea, forms the chief limiting factor of dosage which may be applied to the pelvis. By fractionating and protracting the treatment over a period of six to eight weeks, the danger of bowel injury is reduced and larger dosage may be administered. With further protraction, even larger doses may be given. Thus, over a period of three months, we were recently able to administer with 200 kv., 80 cm. target-skin distance, 2 mm. Cu, 8 r per minute, a total of 2,500 r to each of two anterior and two posterior 15×15 cm. pelvic fields, and 1,400 r through each of two 10×15 cm. sacrosciatic fields; 500 r was added through the perineum a month later. The patient had a frozen pelvis and a recto-vaginal fistula, secondary to a moderately undifferentiated carcinoma of the cervix. Only six months have elapsed, but up to the present no symptoms suggesting damage to the normal tissues from this large dosage have occurred. Incidentally, so far the patient does not show any persistence of disease and the fistula has healed.

A similar protraction of time is indicated in intracervical and intravaginal radium therapy. Failure to observe this precaution may at times result in bowel injury, as emphasized in the report of the Standardization Committee of the American Radium Society published in 1937.

If one reviews the results of Murphy and Hufford, one derives the impression that 400 kv., properly administered, is distinctly worth while in the treatment of cancer of the cervix.

DR. WILLIAM P. HEALY, New York. This series of papers to which we have had the pleasure of listening this morning on the treatment of cancer certainly must be regarded as indicating probably the best that we can hope to obtain with our present methods of radiation therapy and surgery, combined or used singly. We are all agreed that with those procedures we are not able to cure cancer of the cervix in the cases that come to us unless the patient is fortunate enough to come into the hands of the radiation therapist while the lesion is still in an early stage. And even then we cure only about 60 per cent of the cases.

Our results, as far as statistics go, are identical, no matter whether you follow a procedure such as we have been doing at Memorial Hos-

pital of extensive protracted preliminary roentgen irradiation followed by radium, or whether you apply radium first, followed by roentgen irradiation or whether you use radium alone, providing the case is a Stage I case. It seems to me, therefore, that the problem we have to face in cancer of the cervix is one of trying to do something more for the other cases.

I haven't the slightest doubt from our observations at the Memorial Hospital that with the increasing voltage of roentgen rays from 200 kv. to 300 kv. and from that to 400 kv. and then on up to 800 or 1,000 kv., greater benefit will be obtained in treating the more advanced cases and a larger percentage of cures obtained.

The reason for it has been brought out by Murphy and Hufford in their splendid report. One of the important reasons is the fact that with the protracted series of treatments and with the higher voltage and the higher filtration, distinctly less damage is done to the skin fields and apparently the gastrointestinal tract seems to withstand the treatment better.

My impression of the whole question of cancer in the cervix is that we may have a general plan of therapy such as outlined by any one of the speakers here this morning in his particular clinic, but nevertheless each case must be individualized and treated as such.

One of the things that has impressed me is that we are much more apt to overtreat the very favorable case and obtain a radiation slough in the cervix which will be quite some time in healing than we are to undertreat a bad case.

I have had more trouble, therefore, with the very favorable early cases from using more radiation than the patient's lesion required than I have from using heavy dosage in the advanced cases, and I am tremendously in favor of starting every infected ulcerated cancer of the cervix first with roentgen therapy for the reasons mentioned by the speakers this morning who have done that.

I have no argument against following Dr. Taussig's plan if one has a patient available who is a fair surgical risk and has a tumor mass that you regard as a gland lesion in one or both parametria and you think you would like to attempt to remove it; undoubtedly by that method of approach you will save some patients or prolong the lives of some that might have died sooner.

Dr. A. N. Arneson, St. Louis, Mo. There is only one point I should like to add to the discussion of the excellent papers that have been presented. The four essayists have given us comparison of the clinical characteristics and response to treatment noted in different types of gynecologic cancer.

Dr. Bowing has recalled to our attention the occurrence of cancer in young individuals. One would expect such lesions to be of a more anaplastic group, and, therefore, to present a more serious prognosis. It is very gratifying to learn of the surprisingly good results that have been obtained.

In Dr. Taussig's paper we had the opportunity to consider differences in vulvar and cervical cancer. Unsatisfactory results are to be expected among the most advanced vulvar cases which he has classified into Group IV. Among the more favorable lesions, however, the prognosis does not seem to be affected to any great degree by the presence or absence of early lymphatic metastases. It would seem that there must be some differences in the biologic properties of vulvar and cervical cancer, because the invasion of adjacent lymph nodes by cervical lesions does affect prognosis very materially. For a number of years Dr. Taussig has performed iliac lymphadenectomy in the attempt to remove metastases beyond the zone of tissue treated adequately by radium applied to the cervix. He has had more experience with that operation than anyone else, and it will be most interesting to see the final conclusions based on a comparison of his own patients with and without removal of the iliac glands.

Dr. Edwards has emphasized the importance of organization in tumor work, and the value of individualization in planning the treatment of each patient. In most clinics greater effort is being made to preserve the integrity of the tumor bed by reducing the amount of post-irradiation necrosis. Marked destruction of the tumor bed interferes with the orderly processes of regression. In such instances there is usually persistent cancer buried in hard fibrotic tissue. At the same time there is definite relationship between tumor regression and fibrosis occurring under more normal conditions. It is significant, for example, that one rarely sees a good clinical result without considerable foreshortening of the vagina and marked atrophy of the cervix. Every effort should be made to eliminate factors that may interfere with the orderly changes occurring in cancer cells and in the tumor bed

after irradiation. There is evidence that the presence of infection is one of the important factors that tend to lower the threshold for necrosis. The apparent increase in radioresistance noted for infected lesions may be due to a greater amount of necrosis interfering with the orderly changes taking place in the tumor bed, rather than a direct effect upon the cancer cells.

External irradiation has been used to great advantage in the attempt to reduce infection before radium is applied. It seems likely that trans-vaginal, or direct roentgen treatment, will be of marked value in increasing the amount of radiation delivered to the primary lesion. In regard to biologic reactions following different methods of treatment there are two questions I should like to ask Dr. Murphy. They may not be fair ones to ask, because it is almost impossible to compare results obtained from 400 kv. roentgen rays with those following 200 kv. roentgen rays due to variations in dose, intensity, etc. At the same time I wonder if he would hazard a guess as to whether the local reactions within the vagina, such as erythema and edema, were more or less marked with the higher voltage. The second question pertains to patients receiving roentgen irradiation before the application of radium. In those instances I wonder if he was able to detect for the higher voltage a more rapid, or a more marked regression of the primary lesion.

DR. HENRY J. ULLMANN, Santa Barbara, Calif. Before I ask Dr. Murphy the question that I have in mind, I would first like to discuss the possibility of the presence in these bowel reactions of concurrent difficulties.

Within the last six to eight months I happen to have had two that are particularly interesting and I have not heard these complications mentioned, that I can remember, in any meeting.

The first patient developed a diarrhea during the first week or two of her irradiation. Instead of being easily controlled, it became progressively worse, even when the irradiation was stopped temporarily. She also developed violent nausea and vomiting and in about a week recovered and was again given radiation. She took it a little longer and then had another upset. We were able finally, by prolonging the irradiation out of all reason, to give her her course. She went through her radium application, came back for another course of roentgen treatment and went through the same performance, only more severely, and after the irradiation was finished she developed a violent gastrointestinal upset with typical gallbladder symptoms. Operation followed with removal of a stone. Her gallbladder disease was the basis of the whole chain of symptoms.

Within the last three or four weeks I have had another patient who developed diarrhea early and it became persistent. She finished her course but it continued and became more and more violent with cramps. She was found to have an amebic dysentery. Apparently the infection was lighted up by the irradiation.

We must not consider all gastrointestinal upsets developing during a course of irradiation necessarily due to the irradiation alone.

Dr. Murphy spoke of a depth dose of 45 to 48 per cent. I would like to ask if he means that 45 to 48 per cent to be of the dose measured in air or of the total dose; that is, the depth dose proportional to the total skin dose. Most depth dose tables show the depth dose in percentage of the amount delivered on the surface of the phantom or skin, and a 45 per cent dose relative to skin is about a 60 per cent depth dose relative to that measured in air and that is a large difference.

In order not to discredit the increased depth dose with 400 kv., it must be clearly understood what is meant by the percentage depth dose. We get from 45 to 49 per cent and in some instances nearly 50 per cent depth dose in the cervix in a 20 cm. pelvis at 71 cm. through a Thoraeus filter at 220 kv. as actually measured simultaneously with two condenser chambers, one on the abdomen and one in the vagina, corrected for the difference in temperatures. This percentage, it must be remembered, is the percentage of the total or skin dose.

Regarding vaginal applicators; there are not per cent of my patients in whom I could use a colpostat and I much prefer to use individual applicators as they do at the Radiumhemmet, and place them entirely according to the type of cervix and/or lesion, or as might be said according to the art.

I would like to ask Dr. Healy if his 4,000 hours means cervical application alone, or both cervical and vaginal.

DR. DAVID Y. KEITH, Louisville, Ky. I would like to speak primarily of Dr. Murphy's paper. He has been using 400 kv. therapy for approximately four years. I would like to verify his statement that the skin reaction is not an index

to the treatment at all because you do not have any skin damage.

Our filtration is a little greater than his, as well as our filtration of our radium therapy. The difference or change in technique is that we are using a 20 cm. square field and I think it is some advantage in view of what Dr. Taussig has said in regard to lymph node involvement, because by rotating the cone so that the one corner is at the pubes, you can reach the parametria, the lateral wall of the pelvis and also in smaller women you can reach the aortic nodes as well, using anterior and posterior fields.

The other point I wish to speak of is one on which Dr. Arneson touched—the reaction in the vagina. I am quite sure that you can tell a very definite difference if you look at your patient two, three and even four weeks later. You see a radio-endothelitis in the vagina; that the vaginal mucous membrane is decidedly increased in redness. There is a decided difference in that and what we used to see when we were using 200 kv. in these cases.

I also want to say something about radiation sickness. I forget the name of the man in Montreal who gave a report some three or four months ago in the *Journal of the American Medical Association* on the use of nicotinic acid. There is no question that nicotinic acid is a decided advantage in 50 to 75 per cent of the cases, given in doses of three-fourths of a grain about thirty minutes before meals and allow the patient to sip the water that it is dissolved in very slowly—take five to ten minutes to take the nicotinic acid. I am quite sure that there has been a decided decrease of radiation sickness from the use of this nicotinic acid.

Dr. Herbert E. Schmitz, Chicago. I thought it would be of interest to report a similar group of cases that have been treated with 800 kv. roentgen rays and radium and who have survived five years.

In Group I we had 2 cases; 2 have survived.
In Group II, 1 case; 1 has survived.
In Group III, 9 cases with 9 survivals.
In Group IV, 13 cases, 2 survivals.
In these 25 cases, 41.6 per cent have survived five years.

This is a very small group, of a total of 160 cases, of carcinoma of the cervix admitted in 1932 to our clinic. Certain cases were treated with external irradiation alone at 800 kv., others with intravaginal roentgen rays and this group with 800 kv. roentgen rays and radium.

Dr. Murphy (closing). There are one or two points that I think could be clarified: One, the discussion of radium applicators to the vagina. A few years ago I got an idea that these applicators should be made to fit individual cases by making something new in the line of applicators, being used in several places now.

You can buy a gum rubber ball and cut a vaginal applicator and put the radium in any position in the wall of the vagina that you want and it can be so constructed that you can pull your radium through at a little distance or any way you want to and when you get through you can throw it away. The cost is about ten cents for four. Dr. Arneson has been using this idea for some time and he thinks it is all right and so do I.

As we have gotten away from the skin, the bowel has been our controlling factor. I am not in position in my office, with my set-up, to use this, but my idea is this: That if the patient were put in the Trendelenburg position, say fifteen or twenty minutes or even longer before the treatment, and allowed to lie in that position and then moved in on the same table without standing up, and given the treatment in the Trendelenburg position, so far as these bowel changes go I think they could be stopped.

As to the bowel reaction, as Dr. Ullmann talked about these cases, it seemed to me that a year or so ago in the literature from England there were a couple of cases reported of complete ulceration of the small bowel subsequent to small doses of roentgen rays, a certain type of specific reaction which occurred in 2 or 3 cases. There are certain cases that are very sensitive to radiation.

Now, about the skin reaction. I think while we don't worry about it, some people do and the treatment of it is to leave it alone. The first day the patient comes into the office she is told not even to put water on the skin and she doesn't put anything on until we are all through with the reaction. We suggest to patients that they get a box of Johnson & Johnson's baby powder and put that on occasionally and they get along without much trouble.

We use paregoric for the bowel reaction and when we give it we never use less than 1 ounce and usually give it in 2 ounce doses.

The vaginal reaction that Dr. Arneson mentions I think is much sharper in my experience than it ever was with 200 kv. I can't say so

much about that because I am also using larger doses of radiation externally.

As to the matter of the 20×20 cm. field that Dr. Keith mentioned, I tried that on the suggestion of Dr. Quimby and I found that before we got very far, 1,000 or 1,200 r front and back, the bowel reaction was so sharp that I felt we couldn't accomplish as much as we could with the smaller field. I don't believe that the 15×15 cm. field is the ideal, perhaps a 12.5×17.5 cm. may be better.

In regard to these radiation adhesions, and shortening, they are quite marked, as Dr. Arneson said, in all these cases that appear to stay well; we have found a great deal of difficulty in making good cervical examinations in these cases and have discarded the bi-valve speculum. We use a circular, round speculum—just a tube. It is easy with a tube specimen to bring the cervix into view and to break up the adhesions and examine your patient afterwards.

DR. EDWARDS (closing). I would like to add that in many cases of irradiation enteritis, we have noticed a very definite allergic tendency in patients. Whether it is worth anything or not I don't know, but one of them especially, who was allergic to almost anything, suffered with diarrhea for nearly a year.

Another thing is that we found a great many patients who came into the hospital without a history of diarrhea and shortly after starting high voltage roentgen therapy, diarrhea set in and an examination of the stool revealed amebae. This has happened very frequently, so that we have wondered whether or not irradiation might not light up the amebiasis. In many cases the diarrhea was promptly controlled by emetin or some similar drug. These two types of patients—the patient with amebic dysentery and the one with allergic background—are the ones who will most likely suffer from radiation enteritis.

DR. TAUSSIG (closing). Just a word as to the lymph nodes that are involved in cervical and vulvar cancer. I think there is a definite step between the involvement of what we call the first stage lymph nodes and the second stage lymph nodes. In vulvar carcinoma, even in fairly advanced cases, it is rare to find involvement up along the aorta or more distant portions. They are almost always limited to the inguinal canal region, to either side of the external iliac vessels and to the femoral inguinal chain.

In cervical cancer also the involvement is not ordinarily up along the common iliac vessels.

The very careful autopsy studies made many years ago in the Schauta and Wertheim clinics showed definitely that cancer was limited to the pelvis for a very large portion of its progress in the patient—that even at autopsy only one-third of the cases showed involvement outside of the pelvis, so that we need not go up to the region of the common iliac and aorta in order to accomplish something definite in the relief of these lymph node metastases.

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ROENTGEN IRRADIATION OF CELLULITIS ESPECIALLY OF THE FACE AND NECK

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ROENTGEN irradiation of inflammatory lesions was reported as early as 1906 when Coyle[1] reported 3 cases of carbuncles which were treated by roentgen rays. Further progress in the treatment of this type of inflammatory lesion was reported by Dunham[5] in 1916, Ross[15] in 1917, Richards[14] in 1922, and Hodges[7] in 1925. Hodges included in his series a case of cellulitis which responded well to irradiation. However, it remained for Heidenhain and Fried[6] to emphasize the usefulness of the roentgen rays in the treatment of acute and chronic inflammation. They reported 855 cases. Of these 76 per cent recovered without surgical intervention. Holzknecht[11] in 1926 reported that in one-third of his cases the inflammatory process was shortened, in another third of the cases the process was cured in from twenty-four to forty-eight hours, and in the remaining third there was definite improvement.

In the series of cases here presented we are especially concerned with an acute cellulitis of the tissues which surround the alveolar process. This state frequently follows the extraction of teeth with apical abscesses or in the presence of pyorrhea. The cellulitis then spreads into the adjacent structures of the floor of the mouth, the cheek, and into the fascial planes of the neck. When the cellulitis spreads into the floor of the mouth and down into the neck the condition becomes grave. With the development of the cellulitis there is a generalized body reaction of leukocytosis, toxemia, fever, malaise, and a state of anxiety on the part of the patient because of the local necrosis, swelling, and pain, and practically always the inability to swallow, as well as to masticate food, because of the trismus of the muscles. Edema of the glottis is an occasional complication.

The convalescence is always prolonged, especially if the case is moderately severe. The medical treatment instituted often does not bring about quick resolution, or fluctuation. Surgical incision in cellulitis gives no relief because there is no pus present. Until there is fluctuation surgery is not indicated. Frequently in the past medical and surgical treatment has failed to localize the cellulitis. However, by means of roentgen irradiation early resolution or liquefaction may be expected. When the area of cellulitis, following the irradiation, becomes fluctuant, it is then time to open the pus pocket and drain adequately. Large deforming incisions are not necessary, as long as reasonably good drainage is obtained.

The manner in which roentgen irradiation arrests the spreading cellulitis as esplained by Desjardins,[3] May,[13] Heidenhain and Fried,[6] and others, based on the experimental evidence of Warthin,[17] is that the invading leukocytes are readily caused to disintegrate by the irradiation. The sensitivity of these cells has been definitely established by the experiments. It is contended that the lymphatic cell disintegrates in twenty-four hours.

The disintegration of the infiltrating leukocytes and lymphocytes is thought by Desjardins[3] to release into the infected inflamed area a protective substance or enzyme elaborated in the cell which is able to destroy the toxins produced by the bacteria. The liberation of this substance makes it readily available for defensive purposes. It has been shown that the blood becomes bactericidal following irradiation. This is probably due to the absorption of the protective substances from the area of infection as well as from those cells which were disintegrated in the blood stream. It has also been shown that the pus is bactericidal

probably due to the liberated protective substances from the disintegrated leukocytes.

We have a series of 18 cases of cellulitis. All of them involve either the face, the mouth or the neck, or both. Twelve cases followed tooth extraction and intraoral surgery. In 8 of the 12 cases the roentgen treatment was begun by the third day of the onset of the cellulitis. The remaining 4 had first been treated by hot compresses, etc., and these patients had cellulitis for from seven to fourteen days before roentgen irradiation was administered. The response in both groups was satisfactory and resulted in a cure, except in one case. It is true that the earlier the treatment is begun the less chance there is for complications to develop. However, the fact that the disease has been present for several days should not cause a delay in giving the treatments as soon as possible. Keijser[12] reports a case of cellulitis which had been present for three weeks and in which wide incision had been resorted to, but there was no fluctuation or liquefaction until after a series of roentgen treatments.

REPORT OF CASES

CASE I (93079). V. K., admitted on March 30, 1934, with the complaint of pain and swelling of the lower left jaw following the extraction of a tooth three days before. The swelling began the day following the tooth extraction. Examination of the jaw and mouth showed that the mouth could not be opened freely. There was a large area of induration and swelling at the site of the lower left third molar socket. Very little pus was exuding from the socket. Temperature, 102° F.; white blood count, 15,600; urine negative. Diagnosis: Cellulitis of the left lower jaw and face.

Referred to the Department of Roentgen Therapy on March 30, 1934, for roentgen therapy. The patient was treated on this and the following day. On March 31, 1934, a decrease in the swelling of the floor of the mouth made the patient more comfortable and enabled her to take nourishment by mouth. Toxicity was markedly decreased by the third post-irradiation day. By the fifth post-irradiation day the swelling had disappeared and patient was discharged as cured on April 5, 1934 (see Fig. 1).

Treatment was as follows: 2 doses, twenty-four hours apart; seven minutes, 135 kv. (peak); 16 in. focus skin distance, at 5 ma., and 3 mm. aluminum filter.

CASE II (90647). M. B., aged twenty-seven, admitted to the hospital on October 19, 1931, on the surgical service, complaining of a swelling of the face following the extraction of three teeth, three days ago. Examination showed a white adult male confined to bed with fever and a swelling over the lower left mandible. This was red in color, painful to touch and on mastication. The mouth could be opened slightly with difficulty. There was an extensive swelling around the extraction site (lower left molars). This swelling extended backward into the soft palate, and downward into the floor of the mouth, and was beginning to extend into the triangle of the neck. Temperature, 102° F. The white cell count was 24,950. The urine was essentially negative. Diagnosis: Acute cellulitis of the face and floor of the mouth. The patient was referred to the Department of Roentgen Therapy on October 20, 1931, for treatment. A second treatment was given a day later. On October 21 the patient showed considerable improvement after the first treatment. The swelling seemed to be softer and less extensive. The pain was less although not as much as expected. On October 22 the patient expressed relief of pain. The swelling was subsiding. On October 24 the patient was dismissed well on the way to recovery.

CASE III (94534). Mrs. J. H., aged twenty-seven, admitted to the surgical service with the complaint of a swelling of the left side of the face and mandible which had been present for two weeks, but had responded to medical treatment. This swelling recurred after a tooth extraction a few days before. The swelling this time did not respond to treatment. In addition, she developed a fever. Examination showed a young adult female confined to bed with an acute illness, having fever, pain, and an extensive swelling of the left side of the face, extending from left superciliary ridge to a point in the neck just slightly below the mandible. This swelling was very painful and firm, as well as hot to the touch and red in color. The mouth could not be examined well because of the difficulty in opening. The temperature was 102° F. The white cell count was 21,850, and the red cell count 5,550,000. Urine was essentially nor-

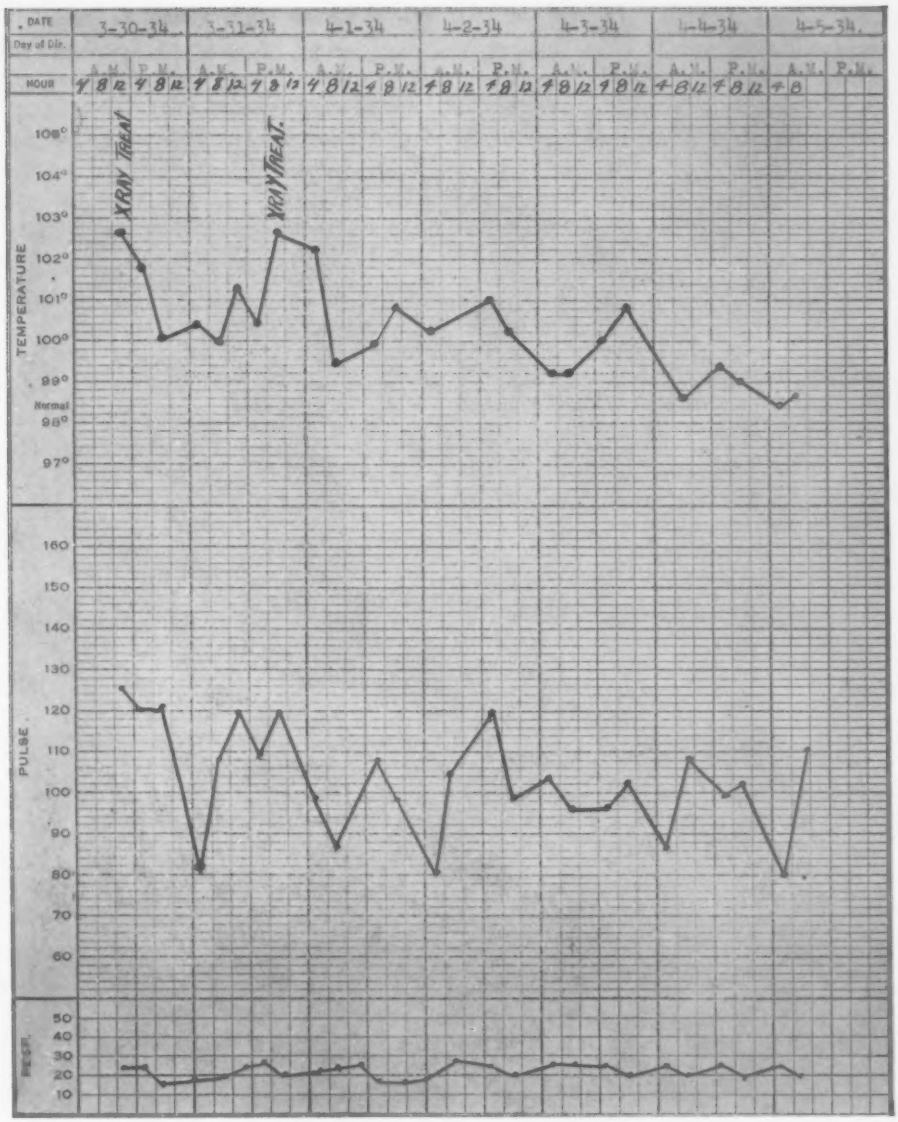

Fig. 1. Case 1. Temperature record.

mal. A smear from what purulent material could be obtained showed gram-positive cocci, many streptococci, and gram-positive bacilli. Diagnosis: Cellulitis of the face. On June 8, 1934, the patient was referred to the Roentgen Therapy Department for treatment of the cellulitis. The treatment was given the day the patient was first seen and 231 r was administered to the area. A second dose of the same amount was given forty-eight hours later. The other treatment factors: 135 kv. (peak); 3 mm. aluminum filter; 14 in. focus skin distance; 5 ma.

The first day after irradiation the temperature fluctuated between 100 and 102° F. In the evening of the first post-irradiation day the patient was able to open her mouth more freely and with considerably less pain. On the second post-irradiation day a second dose was delivered to the area. In the evening of this day stab incisions were made intraorally as the area had become fluctuant, and pus could be expressed from the incision. Five days after the roentgen treatment had been started the temperature had fallen to 99.8° F. Pus was still draining. The patient was dismissed on June 15 and further convalescence was normal.

Case iv (101913). Mrs. B. R., aged forty-five,

admitted to the service with a complaint of a large tender swelling along the left mandible and extending into the soft tissues of the neck, and floor of the mouth. Three days before a tooth had been extracted. Examination showed considerable trismus of the mass of the masseter muscle. The tongue was elevated above the teeth margin and the floor of the mouth was firm and swollen as well as painful. Externally the swelling extended over the left mandible and upward to the hairline and downward into the tissues of the neck, and posteriorly over the mastoid region. Anteriorly the swelling extended slightly over the midline. Blood findings showed a white cell count of 13,650 and a red cell count of 4,470,000; hemoglobin, 85 per cent. Highest temperature before treatment on day of admission was 102.4° F. Urinalysis: specific gravity 1.030, a trace of sugar, and one plus albumin. Diagnosis: Early Ludwig's angina. The patient was referred to the Roentgen Department on July 9, 1935, for treatment of the cellulitis. A dose of 289 r was delivered to the area and a second dose of 193 r was delivered to the same area forty-eight hours later. The irradiation was followed with local applications of alcohol dressings to satisfy the family. In twenty-four hours after the first roentgen treatment there was a marked relief of pain. Also pus began to exude from the alveolar cavity. The temperature fell more gradually and had become normal by the seventh day. Further recovery was uneventful.

CASE V (103489). H. S., male, aged twenty-nine, was admitted to the surgical service with the complaint of swelling of the right jaw which had developed following an extraction of an impacted third molar. Extraction was under local anesthesia.

On examination there was a hard painful swelling over the mandible, which caused the patient considerable pain on opening his mouth. Temperature, 100° F. The patient felt malaise and was confined to bed. The blood examination showed a white cell count of 12,100 and a red cell count of 4,970,000. Urine examination was essentially negative. Diagnosis: Cellulitis following tooth extraction. The patient was referred to the Roentgen Department for therapy. On this day a dose of 289 r low voltage technique (135 kv.) was delivered to the area of cellulitis. A second dose of 193 r was delivered to the area forty-eight hours later. At first there was considerable increase in the pain. This was present especially during the first eight to ten hours after irradiation. Morphine was used to control the pain. The following morning, i.e., twenty-four hours after the treatment, the patient expressed considerable relief of the pain. This was associated with the beginning flow of free pus. The swelling also began to decrease. On the fourth post-irradiation day there was little or no discharge from the tooth socket. The swelling at this time had practically disappeared. Temperature was normal by the fourth day.

CASE VI (103549). Mrs. R. K., aged forty-four, was admitted to the surgical service on September 20, 1935, with a complaint of an extensive swelling below her chin and involving the mouth. This was very painful. The swelling began two days after the removal of a stone from the sublingual gland. Examination showed a female acutely ill in bed with an extensive swelling in the floor of the mouth elevating the tongue and extending backward into the neck. This swelling was palpable externally and was firm as well as hot to the touch. There was considerable redness of the area. Swallowing was difficult. Breathing was regular but somewhat difficult. Sitting upright seemed to ease the patient. Temperature, 101.4° F. The blood findings were: white cell count 18,600 (see Fig. 2). Diagnosis: Ludwig's angina.

This patient was referred to the Roentgen Therapy Department on September 20, 1935, for irradiation. A dose of 289 r was given over the involved area with the factors of 135 kv. (peak); 5 ma., 16 inch focal skin distance, and a filter of 3 mm. aluminum. A second dose of 193 r was given forty-eight hours after the first treatment. There was little or no relief the first eighteen hours. Preparations for tracheotomy and intubation were made because of the increased difficulty of breathing. However, after twenty-four hours pus began to exude from the floor of the mouth and there was some relief of pain. This was twenty-four hours after irradiation. By the time the second dose of radiation was to be given the patient had improved considerably. The swelling was less but still extensive. The temperature began to fall after the second treatment. The fifth post-irradiation day the patient was dismissed with a temperature almost at normal (see Fig. 2) and the swelling had practically disappeared.

CASE VII. Mrs. E. C., aged twenty-three, admitted to the Roentgen Therapy Department

as an outpatient with the complaint of a red painful swelling which followed the extraction of a devitalized abscessed tooth. Onset of swelling was a day after the extraction. Referred for roentgen therapy by Dr. P. G. Papsdorf. Examination on May 24, 1935, day of admission, at 14 inch distance, with 3 mm. aluminum filter and 135 kv. (peak) at 5 ma., over an area that was approximately 15 cm. square. The patient was then dismissed to return home and an appointment was made to return for further treatment within forty-eight hours.

Fig. 2. Case VI. Temperature record.

showed an extensive swelling of the right side of the face, extending into the neck in the region of the angle of the jaw. The floor of the mouth appeared to be involved. The patient seemed acutely ill and to have a fever. Swallowing was difficult and painful. The patient was treated by superficial roentgen therapy technique, 289 r

At home the patient became worse. The fever rose and the patient had severe chills. The referring physician was notified and he advised hospitalization—the patient however decided to call another physician. He advised hospitalization and advised the patient to be admitted to a neighboring hospital (Englewood). On ad-

mission to the hospital the swelling had extended into the neck. The patient was definitely more toxic and now had a temperature of 102° F., with a pulse of 124. The urine showed a trace of albumin and acetone. There were 8 to 10 white blood cells per high power field, and an occasional red blood cell. The blood findings were as follows: white blood count, 16,400; red blood count, 4,700,000; hemoglobin, 85 per cent. Differential: neutrophils, 80 per cent; lymphocytes, 17 per cent; monocytes, 3 per cent. Diagnosis: Cellulitis of neck and floor of mouth; Ludwig's angina.

The patient was referred to the Roentgen Department of a neighboring hospital and received a second dose of radiation on May 27, 1934. The patient did not respond to the treatment and became gradually worse, and died on May 28. Necropsy performed by Dr. P. A. Delaney.

Anatomical diagnosis: Ludwig's angina, diffuse suppurative cellulitis with abscess formation and gangrene involving the soft tissues of the neck bilaterally in and about the submaxillary triangles. Recent extraction of the first molar with denudation of bone. General lymphadenitis, acute lobar bilateral pneumonia. Blood culture showed *Staphylococcus aureus*.

CASE VIII (99276). E. R., male, was admitted to the hospital with the complaint of a swelling in the left side of the face and neck. This swelling had become severe after the extraction of an abscessed root under gas anesthesia. The roots had been present for about ten years when two weeks ago his face began to swell. Roentgen examination at this time showed the abscessed roots of a molar tooth. The day following his face began to swell, and extended into the neck.

Examination showed an adult male, acutely ill, with fever and an extensive swelling of the right side of the face extending from the temporal region down into the submaxillary triangle of the neck. The left eyelids were swollen shut. The mouth could be opened with difficulty. There was only a small amount of purulent discharge from the mouth. Temperature, 104° F. Blood examination: white blood count, 23,500; red blood count, 5,100,000; hemoglobin, 85 per cent. Urinalysis: acid reaction, specific gravity, 1.038, a three plus albumin reaction, Benedict's solution reduced in one-half minute. Microscopic examination showed only a few white blood cells and 2 to 10 red blood cells per $\frac{1}{6}$ field. Diagnosis: Cellulitis of face and neck.

On the day of admission the patient was referred to the Roentgen Therapy Department and given 289 r within forty-eight hours. There was increase in pain and difficulty in swallowing after the treatment. This was relieved the following morning. Morphine sulphate was used to control the pain. The day of the second treatment, i.e., forty-eight hours after the first dose, the patient appeared greatly relieved from pain and the swelling seemed to be at a standstill and slightly decreased. The patient was less toxic. The third day after the first roentgen treatment an extraoral incision was made and drains inserted. Three incisions were made and free drainage obtained. White blood count, 21,050. Large amounts of pus were evacuated so that by the twelfth post-irradiation day the white blood count had dropped to 16,250. The temperature had now dropped to normal and occasionally to below normal. Patient dismissed for home. Further convalescence normal.

CASE IX (98749). F. L., white male, single, aged twenty-four, was admitted to the surgical service with the complaint of a painful swelling of the left side of the face for the past ten days following the extraction of a tooth, lower third molar. Fifteen days ago the third molar on the left side was extracted. For five days the area was tender, painful and swollen. Hot applications were used and on the thirteenth day a small amount of pus exuded from the socket. Examination showed an adult male, acutely ill in bed with a swelling of the left side of the mandible, extending into the maxillary triangles of the neck. There was a small amount of purulent exudate coming from the tooth socket of third lower left molar. Temperature 102.8° F. Blood examination showed a white count of 14,500. Urine examination essentially negative. Diagnosis: Cellulitis of the left side of the face and neck extending from the infected socket. Patient referred to the Roentgen Department January 18, 1934. Temperature began to fall twenty-four hours after treatment and became normal on the third day.

CASE X. A. L., white female, single, aged twenty-four, was admitted to the hospital with a complaint of swelling on the right side of the face and neck for the past ten days. A slight purulent discharge was present coming from the lower second molar tooth socket. On February 5, 1935, the second lower right molar was extracted. Three days later a swelling developed

at the site of extraction. This was lanced but no pus could be obtained. The swelling grew progressively worse with medical treatment. Examination of the mouth showed the mucous membrane on the right side to be swollen and reddened along the tooth socket of the extracted tooth. A small incision was present along the buccal fold. Externally the swelling extended from the hairline on the right side of the face to and into the submaxillary triangle on the right side of the neck, and below the mandible. The white blood count was 15,900 and the red cell count 4,350,000. Urine examination showed a two plus albumin reaction, acid, and specific gravity 1.028. Diagnosis: Cellulitis of the face and neck. Patient was referred to the Roentgen Department for treatment. Two treatments were given. Within forty-eight hours there was a free flow of pus; within twenty-four hours there was relief of pain so that no narcotics were necessary. Temperature fell within twenty-four hours and at forty-eight hours was almost normal. There was no further rise and patient was dismissed on the fifth day. (From the service of Drs. Share and Gilmore.)

Case xi. Mrs. M. S., aged twenty-one, admitted to the hospital on June 5, 1935, with a large swelling of the left side of the face and neck. This had been developing since May 31 and had now spread into the neck. Previous to the swelling a tooth had been extracted. Examination of the mouth was difficult. It did show an extensive induration and swelling of the floor, causing the tongue to be elevated. No purulent discharge was present. Temperature, 101° F. The white blood count was 13,450 and the red blood count 5,120,000; hemoglobin, 90 per cent. Examination of the urine showed it to be acid, with one plus albumin reaction, but no reduction of Benedict's solution. Microscopic examination of the urine showed a few leukocytes and erythrocytes per high power field. Diagnosis: Cellulitis of the face, neck, and floor of the mouth.

Patient was referred to the Roentgen Department on June 5, 1935, and a treatment of 289 r was given. After forty-eight hours a second treatment of 193 r was given. Within twenty-four hours after the first treatment the swelling began to resolve and there was definite decrease in pain. The patient improved so rapidly that she went home shortly after the second treatment. Further convalescence was short and recovery complete.

The following case comes in the general group of those patients who were treated after the cellulitis has been present for more than seven days, in this instance fourteen days. This particular case is unique in that there was a recurrence which went on to suppuration.

Case xii (102740–103758). P. G., aged nineteen, white female, single, admitted on August 14, 1935, and on September 5, 1935, to the hospital on the surgical service with a painful swelling of the right jaw which developed shortly after tooth extraction and which for the past fourteen days had not responded to medical treatment, but was becoming worse. Previous to the tooth extraction there had been several attacks of swelling but they had subsided and it was during this period that the extraction took place. The tooth was an impacted third molar around which the gum frequently became swollen. The patient was confined to bed with a brawny swelling over the right side of the face, extending over the parotid region and mandible and into the neck. There was extreme tenderness and difficulty in swallowing and in mastication. Inspection of the mouth showed considerable induration and inflammatory swelling around the tooth socket. From the socket a brownish serum exuded, but no frank pus. Temperature was 100° F. Blood examination showed a white cell count of 8,800 and red cell count of 4,700,000; hemoglobin, 85 per cent. Urinalysis was essentially negative. Diagnosis: Cellulitis of the face and neck with abscess formation.

Patient was referred to the Roentgen Department on August 14, 1935, and given a series of roentgen treatments over the right side of the face and neck. The first dose was 289 r, with a second dose of 135 r forty-eight hours after the first dose. Hot magnesium sulphate compresses also were used. The day following treatment the patient was very apprehensive. Temperature rose to 101° F., and on the second day to 102° F., associated with more swelling. The swelling began to diminish on the second day of hospitalization. The patient went home on the fifth day with a temperature of 99.8° F. At home the swelling at first seemed to subside but recurred so that the patient was forced to return to the hospital on September 5, 1935. A point of fluctuation was found and incised, pus expressed and drainage established. A second in-

cision was made at a second fluctuating point, following which the patient made an uneventful recovery.

The cases above reported are those of cellulitis which followed tooth extraction. However, cellulitis may follow any slight abrasion or laceration. We have 4 cases to present in which there was but a trivial injury antecedent to the development of the cellulitis. At times it is difficult to find the source of the infection.

CASE XIII (92137). O. C. D., aged six, white male, was admitted to the hospital on the service of Dr. G. E. Johnson with the complaints of fever, chills, difficult swallowing and mastication, and a swelling just below the chin and the right side of the face. This began three days before and was preceded by an abrasion of the skin the day previous.

Examination showed a white male child acutely ill in bed with a temperature of 101° F., and a swelling which involved the floor of the mouth and the right side of the face. On the chin was a small abrasion, from which the swelling extended as described above. Diagnosis: Ludwig's angina.

The patient was referred to the Department of Roentgen Therapy on January 28, 1934, for irradiation. Two treatments were given twenty-four hours apart. There was improvement in the general condition the following day with relief of considerable amount of the pain. Swelling and pain had decreased to the extent that eating, mastication, and swallowing could be resumed. Patient was allowed to go home on the third day, with a temperature of 100.1° F., because of the insistence of the parents. However, the convalescence was short and recovery was complete in a few days.

CASE XIV (93797). P. G. P., male, aged forty-three, admitted to the hospital May 7, 1934, with a swelling of the face in the region of the left malar bone in the center of which was an abrasion. Two days ago the patient was struck by a garden hose and the swelling began a day later.

Examination showed an adult male with an extensive reddened swelling involving the left eye and malar region, with an abrasion in the center of this area. Temperature, 99.8° F. White blood count, 12,300; red blood count, 4,800,000. The urine was essentially negative. Diagnosis: Cellulitis of the face.

The patient was referred to the Department of Roentgen Therapy for treatment on May 7, 1934, at which time he was given ¾ S.E.D. at 5 ma., 135 kv. (peak), 14 inch distance, 3 mm. aluminum filter. There was a rise in temperature following this treatment to 103° F. but shortly thereafter it fell to normal. A second treatment of ½ S.E.D was given forty-eight hours after the first. Fluids were forced and hot applications continued. Patient dismissed from the hospital the following day.

CASE XV (99873). E. S., aged eight, admitted to the hospital on the service of Dr. F. Muller with pain and swelling of the left eye and face. Five days before the child was struck by a stone which abraded the skin above the left eye. Antiseptics were used to clean and dress the wound, but in spite of this there developed a moderate redness and swelling of the tissue around the abrasion. No pus was present. The eye became swollen and the patient felt feverish. Examination showed a small puncture wound of the skin above the left eye in an area of extensive swelling, which was red and painful, and hot to the touch. Temperature 103° F. White cell count, 20,000; red cell count, 4,860,000; hemoglobin, 85 per cent. The urine showed a one plus albumin reaction, but was otherwise negative. Diagnosis: Cellulitis of the face, possibly erysipelas.

Referred to the Roentgen Therapy Department for treatment on March 24 and 26, 1935. Considerable relief was obtained in twenty-four hours and the swelling began to recede. White blood cells 13,600. On the following day a small amount of seropurulent material could be expressed from the wound and by March 27 there was more discharge and the swelling began to decrease in size.

It is not always necessary that there be trauma in the immediate vicinity or in the center of the area of cellulitis. Moreover the source of infection is not always demonstrable. This is illustrated by the following case:

CASE XVI (103764). P. O'D., white male, aged forty-five, admitted to the hospital October 5, 1935, because of a painful swelling to the lower left jaw and neck. This began seven days ago, and became progressively worse regardless of treatment. There was no discharge from this area. Examination showed a red, indurated swelling extending over the left mandible and

into the submaxillary triangle of the neck on the left side. There was no point of fluctuation. Teeth appeared normal. Temperature 101° F. White cell count 20,250.

Patient was referred to the Roentgen Department on the day of admission and received 289 r. Forty-eight hours later he received an additional 193 r. He improved rapidly and was dismissed.

In one of our cases an area of cellulitis developed quite remotely from the area of trauma and cellulitis. In this case it seemed that this metastatic spread of the infection must have been by the blood stream. The case follows.

Case xvii (98404). M. H., female, aged five, was admitted December 29, 1934, to the hospital on the surgical service with the complaint of a swelling in the neck. This swelling had been present for three weeks; it was incised on the day of admission and a seropurulent fluid was obtained. This showed streptococci. Two days later an area of swelling developed in the dorsum of the right foot. Roentgen examination showed no bone involvement by the infective process.

Examination showed a draining sinus of the neck; an area of redness and cellulitis on the dorsum of the left foot. This cellulitis became more severe. White blood count on January 5, 1935, 29,300. Temperature at this time was 103.8° F. The patient was referred to the Roentgen Department for therapy on January 5. A dose of 289 r was given. A second dose of 193 r was given on January 7. The temperature began to fall in twenty-four hours, it did not rise above 102.6° F. On the second day after the second dose was administered the temperature fell to a level of 101.6° F. and then again fell to 100° F., at which point it remained constant for four days. The cellulitis showed a rapid decline. No suppuration took place in the foot. The neck continued to drain. On January 14 the patient was removed from the hospital because of finances. The foot had cleared up. The white cell count was 10,500 on the day of dismissal, and the temperature was 100.4° F.

Cellulitis repeatedly follows the opening of an infected area. We wish to present such a case in which we feel recovery would have been doubtful if roentgen therapy had not been resorted to. This case is one in which a mastoidectomy had been performed about fourteen days previous to the time that there developed a cellulitis in the neck extending downward from the skin incision over the mastoid.

Case xviii (98864). Mr. C. V., white adult male, aged twenty-six, was admitted to the hospital on January 24, 1935, with the complaint of a tender left ear. He was placed on the surgical service and an operation of the left mastoid was performed. Suppuration and breaking down of the bony structures had taken place. About ten days after the operation a mass was found in the neck just below the incision. This was incised. The following day the entire left face and neck were red, indurated, and the infection seemed to be spreading rapidly in all directions. Temperature before the incision of the apparent abscess was 102.4° F. and the day the extensive cellulitis of the neck was found was 104° F. rectally. The white cell count was now 33,500. Diagnosis: Cellulitis following mastoidectomy.

The patient was referred to the Roentgen Department for therapy on February 7, 1935. A dose of 289 r was given, with 5 ma., 14 in. distance, 135 kv. (peak), and 3 mm. aluminum filter. After forty-eight hours the treatment was repeated with the same factors except that the dose was reduced to 193 r. In addition 50 cc. of whole blood was injected intramuscularly. The temperature began to fall the third day after the first roentgen treatment. It fell to 102° F. and rapidly dropped each day until on the sixth day after irradiation was started it reached 99.4° F. Recovery from this point on was uneventful.

RESPONSE TO IRRADIATION

In the 18 cases here reported, the response to the radiation begins within twenty-four hours. The patient first experiences an increase in pain and at times an elevation of temperature. This increase in pain persists for about six to ten hours and sometimes twelve. In twenty-four hours the relief of pain is usually remarkable. Table 1 indicates that relief of pain occurs not earlier than twenty-four hours after treatment. This is not entirely true. Since the patients experience considerable increase in the pain in the first twelve hours it has been the custom to give morphine in doses ade-

quate for relief. Hence the entire effect would not be worn off before a period of twenty-four hours. In our series of cases here reported we find that 14 of the 18 cases showed definite relief of the pain within the twenty-four hour period, whereas only 3 report relief not earlier than forty-eight hours after the administration of the first dose of radiation. As will be noted one case did not report relief of pain at any time. This patient died due to the infection and complications that set in.

Relief of pain may be said to be one of the outstanding effects of irradiation in cases of cellulitis (Table 1). There is also a decrease in the amount of swelling,which is noticeable in twenty-four to forty-eight hours. With this decrease in swelling the patient begins to feel an improvement; and is less toxic. In this series there were 9 cases in which a decrease in the extent of the swelling occurred within twenty-four hours; 7 cases showed a decrease in swelling after forty-eight hours.

This swelling is not always absorbed. Absorption without suppuration occurred in only 7 cases. In 10 cases fluctuation occurred and opened spontaneously or was incised.

Occasionally after a swelling (inflammatory) has been absorbed or nearly so, there may be a recurrence of the cellulitis. This happened in one of our cases.

TABLE I

COMPILED DATA ON CASES OF CELLULITIS

Case No.	White Blood Cells	Highest Temperature on Admission	Number Hours before Temperature Fell	Hours before Relief of Pain	Day of Purulent Discharge	Day of Incision to Evacuate Pus	Hours before Swelling Decreased	Days of Hospitalization	Remarks: R—recovered D—deceased	Temperature at Time of Dismissal
I	15,600	102.4	72	48	4th	—	48	6	R	
II	24,950	102.6	48	24	—	—	24	6	R	99.
III	21,850	104.	48	24	3rd	3rd	24	7	R	98.6
IV	13,650	102.4	24	24	2nd	—	24	8	R	100.4
V	12,100	100.	48	24	2nd	—	48	4	R	98.6
VI	18,600	101.4	48	48	2nd	—	48	5	R	98.6
VII	16,400	102.	—	None	None	None	—	4	D	
VIII	23,500	104.	120	48	4th	4th	48	12	R	97.8
IX	14,350	102.8	72	24	2nd	—	24	7	R	98.6
X	15,900	103.	24	24	—	—	24	7	R	98.6
XI	13,450	99.8	96	24	—	—	24	3	R	102.
XII	8,800	100.	120	48	—	4 wk.	48	20	R	99.8
XIII	—	103.6	48	24	—	—	24	3	R	100.
XIV	8,800	99.8	96	24	—	—	24	3	R	98.6
XV	13,600	103.	48	24	2nd	—	24	3	R	98.6
XVI	20,700	101.	48	24	2nd	—	24	4	R	—
XVII	29,300	103.8	24	24	—	—	24	15	R	100.4
XVIII	33,500	104.8	72	24	2nd	—	48	20	R	99.

The temperature of the patient gives an index of the state of health. In these cases of cellulitis the temperature ranged from 99.8 to 104° F. Progress in the cure of the infection is also recorded in the study of the temperature. Usually when the temperature begins to fall toward normal we say the condition is more favorable to recovery. In 2 cases out of the 18 here reported the temperature began to fall on the first day after the initial irradiation. When this occurred one could be fairly certain that there would be little or no suppuration. Six cases showed a fall in the temperature curve on the second day after irradiation,

and 3 on the third post-irradiation day; 2 cases showed a fall on the fourth and fifth day after irradiation.

It is not always possible for patients to remain in the hospital as long as it may be best. For economic reasons mainly many of our patients left the hospital with an elevated temperature. Nine of our cases had a temperature which varied only 0.2° from the normal. Four patients had a temperature above 100° F., and in but 3 cases was the temperature between 99 and 100° F. and in one the temperature at dismissal was 102° F. Out of these cases only one (Case XII) had a recurrence. In this case the temperature was 99.8° F.

TECHNIQUE OF TREATMENT

The degree of the cellulitis in the various patients varies as well as the general response to the infection. We always attempt to treat the entire area at one time. This is easily done when the cellulitis confines itself to a small area, or one at least not larger than 20×20 cm. If a larger area than this is encountered it is obvious that it must be divided into two parts. Oftentimes when dealing with a cellulitis of the face or neck it may be necessary to treat both sides. However, we have not been in the practice of treating a patient over more than two areas at a time, no matter if they are contiguous or not. If it is necessary to treat more than two areas at a time it is well to decrease the dose over each area.

The initial dose in our series is a rather heavy dose of approximately ¾ S.E.D. This is given in an attempt to destroy as many of the invading leukocytes as possible and liberate the greatest amount of the protective substance. We have therefore been giving our patients in this series an initial dose of 289 r, measured in air. After forty-eight hours we have again treated the area of cellulitis but this time the dose has been reduced to 193 r, or about ½ S.E.D. The other factors are as follows: 135 kv. (peak), 5 ma., 35 cm. (14 in.) focus skin distance, 3 mm. aluminum filter. At this potential we felt that the tissues to a depth of 3–5 cm. would receive the greater portion of the radiation and the tissues lying below this level would not be injured.

The total dose is given within forty-eight hours and not less than thirty-six hours elapses between doses. Cushway and Maier[2] give a full erythema dose which cannot, therefore, be repeated for approximately thirty days. This, however, is usually not necessary.

CONCLUSIONS

1. The treatment of choice in cellulitis is irradiation which shortens the illness by causing early resolution through the fact that protective substances are liberated from the destroyed leukocytes.

2. Relief of pain occurs soon after irradiation and is of great benefit to the patient mentally and physically. This relief of pain occurs when either resolution or liquefaction takes place. The early liquefaction of the area may necessitate small incisions to give drainage.

3. No extensive surgical incision is necessary. If an area goes on to fluctuation and pus formation, from one to three small incisions to allow drainage may be necessary.

4. The temperature decreases in a few days as resolution occurs.

5. The toxicity of the patient decreases because of absorption of the liberated protective substance as the blood becomes bactericidal.

6. Hospitalization is at a minimum. Many cases may be treated as out-patients.

I wish to thank Dr. P. G. Papsdorf and the attending staff of the Evangelical Hospital for permission to use their cases.

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THE ROENTGEN DIAGNOSIS OF NONOPAQUE FOREIGN BODY IN THE LOWER RESPIRATORY TRACT

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THE diagnosis of a foreign body in the larynx, trachea or bronchus is a not uncommon problem encountered by the roentgenologist. When the foreign body is opaque to roentgen rays, a correct diagnosis is usually not difficult. The presence of a semi-opaque or nonopaque foreign body, on the other hand, presents considerable diagnostic difficulty, and unless the roentgenologist is thoroughly familiar with the correct method and technique of examination, as well as skillful in the interpretation of his findings in these cases, his percentage of failure to reach a correct conclusion will be high.

Nonopaque foreign bodies usually consist of some form of vegetable matter and they have an effect on the respiratory tract which is vastly different from that caused by inorganic opaque foreign bodies. To the mechanical effects from the bulk of the foreign body is added a factor of irritation causing a diffuse inflammatory reaction which involves the whole tracheobronchial tract. This is due to the spread to both lungs of an irritating oil peculiar to the vegetable matter present.[5,20] The reaction is early and violent, and unless the foreign body is promptly diagnosed and removed, it may be quickly fatal. If the foreign body carries infection with it, the reaction will be even more severe.

Since nearly 50 per cent of foreign bodies found in the respiratory tract are of the nonopaque type, the importance of a correct diagnosis is obvious, and a summary and discussion of the present knowledge of this subject, placing special emphasis on its less familiar aspects, is deemed timely.

The history is often very helpful and may be almost diagnostic in itself. A negative history has no negative value. Typically, there is a history of a sudden violent onset after previous good health, with coughing, choking and gagging, accompanied by more or less respiratory difficulty. These onset symptoms subside after a short time only to reappear in a few hours, rarely, if ever, more than twenty-four hours.[18] The patient then complains of paroxysmal cough, increasing dyspnea and exhaustion. The symptom-free interval occurs in nearly every case, and if the patient is seen at this time, one should be very careful about assuming that the foreign body has been spit out or has entered the esophagus instead of the trachea, and that the danger is over.

A brief physical examination should be made by the roentgenologist. Inspection reveals in most cases a restless patient with anxious facies and more or less cyanosis. Expansion of the affected side is limited. Respiration is rapid and jerky and is often accompanied by wheezing which may be inspiratory or expiratory or both. Asthmatoid wheeze, audible slap or palpatory thud as described by Jackson and Jackson,[7] if present, is considered by them as being pathognomonic of tracheobronchial foreign body.

Obviously the physical signs will depend on the location, size, shape and nature of the foreign body. They may change rapidly from hour to hour or moment to moment. In fact, rapidly changing physical signs are very indicative of the presence of a foreign body in the respiratory tract.

The roentgen examination should begin with a thorough roentgenoscopic study. If possible, the patient should be examined in

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both the erect and supine positions. The patient should not, however, be moved more than is compatible with a complete examination because a dislodged foreign body may be very dangerous if it lodges in the contralateral bronchus or blocks the trachea or larynx.

Roentgenoscopy is particularly important in these cases because it is the best means of studying the complete respiratory cycle over and over again. In this way slight abnormalities of respiratory movement are often noted which it would be difficult or impossible to demonstrate on roentgenograms. These are best seen when the patient's inspiration and expiration are full and complete. Therefore an infant who does not cry during the examination should be gently stimulated to do so. The roentgenologist should repeatedly assure himself during the examination that the patient has not turned from a true anteroposterior position.

The making of roentgenograms then completes the examination. The roentgenologist, guided by his roentgenoscopic observations, should supervise the making of the roentgenograms. Accurate and precise technique is of the utmost importance. In general, the following technique is advisable.

The patient should be placed accurately in the anteroposterior position in relation to tube and film. This is of extreme importance if slight shifts of the mediastinum are to be detected.

Two exposures should be made, one at the end of full inspiration, the other at the end of full expiration. Suitable roentgenograms may require a great deal of patience and some repetition when the patient is too sick or too young to cooperate by holding the breath on command. The technical factors for both exposures should be identical, as it is essential that the two roentgenograms be comparable. Exposure should be at full expiration if only one roentgenogram is made, because slight degrees of hyperaeration and abnormalities of position of heart and diaphragm show best on expiration. Exposure time should be one-tenth second or less. Lateral and oblique positions should be used if needed to demonstrate unilobar involvement.

The roentgen signs also depend on the location, size, shape and nature of the foreign body present. The early signs are essentially those of incomplete or complete obstruction at some point along the lower respiratory tract. The later signs are those of the complications resulting from obstruction and infection; that is, pulmonary abscess, bronchiectasis, and drowned lung. The foreign body itself, being nonopaque to roentgen rays, will naturally not be visualized.

Incomplete obstruction may produce either atelectasis or emphysema of the lung distal to the point of obstruction. This is due to the check valve action of the foreign body, which may allow air to enter the lung distal to it and not allow its expulsion, or vice versa[7] (Figs. 1, 2 and 3).

If obstructive emphysema is present, the following signs are noted. At the end of full inspiration, unless overinflation is marked, the affected area shows no increase in transparency, the ribs are in their normal horizontal position with wide intercostal spaces, the mediastinum is in normal position, and the diaphragm is at its normal level. At the end of full expiration the affected area shows an increase in transparency while the transparency of the surrounding or opposite unaffected lung may show slight decrease from the normal; the ribs over the affected area remain in their horizontal position with widened intercostal spaces; the mediastinum shifts away from the affected area; the diaphragm on the affected side is depressed, and on the unaffected side is at the normal level. The prominence of these signs depends on the size of the affected area and the length of duration and degree of obstruction.

Endobronchial neoplasms and extrabronchial lesions causing compression stenosis of a bronchus also cause obstructive emphysema.[13] These conditions, however, usually occur in adults, whereas 90 per cent

of nonopaque respiratory foreign body accidents occur before the age of three.[15]

The presence of an obstructive emphysema even without a typical history is always sufficient to make a presumptive diagnosis of bronchial foreign body.

A moderate degree of emphysema may persist after removal of the foreign body, due to swelling of and exudate in the bronchus, caused by the chemical irritation of the intruding substance. If the signs increase or persist more than a few days, the

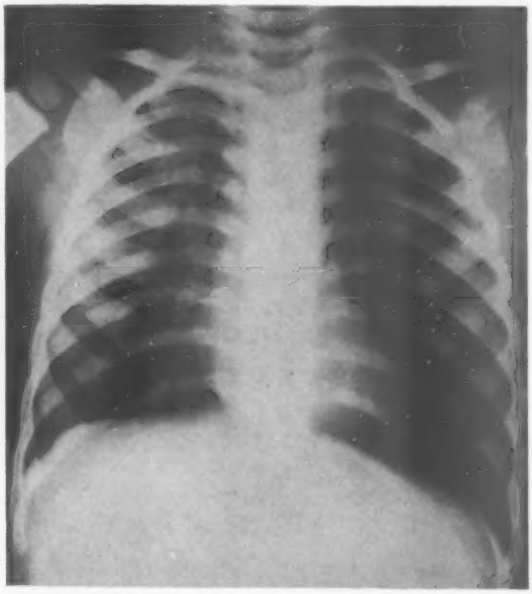

Fig. 1. Inspiration. Obstructive emphysema, left lung. Peanut in left main bronchus.

diagnosis should again be considered positive.[9]

If the point of incomplete obstruction is in the larynx or trachea, bilateral emphysema will develop. In this condition the roentgen examination shows more than the normal amount of residual air present in both lungs at the end of full expiration. There is limitation of motion of the diaphragm on both sides, and it may be at a lower level on expiration than on inspiration. There is little change in the position of the ribs, the transverse diameter of the chest being only slightly narrower on expiration. There is no mediastinal shift on

Fig. 2. Expiration. Same case as Figure 1. Note accentuation of the signs of obstructive emphysema.

inspiration or expiration. The heart appears normal on inspiration, but transverse measurement shows a marked decrease on expiration. This has been shown experimentally to result from a squeezing of the

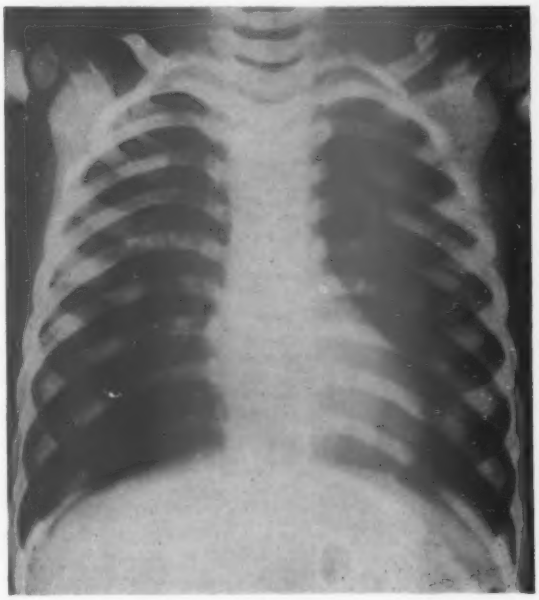

Fig. 3. Same case as Figures 1 and 2. Three days after removal of peanut from left main bronchus.

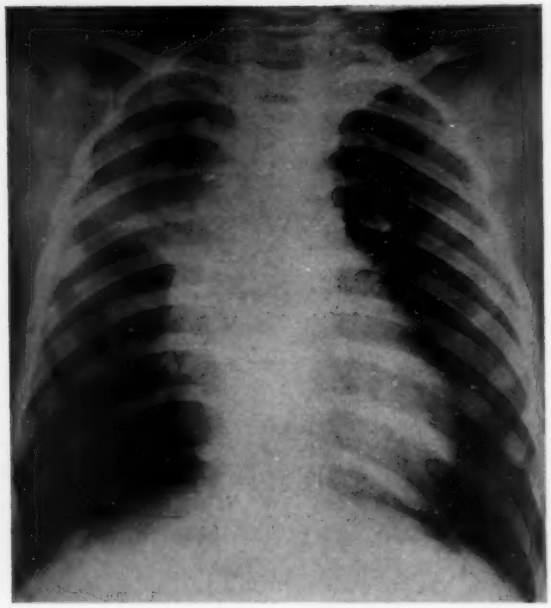

FIG. 4. Inspiration. Bilateral obstructive emphysema. Disintegrating vegetable material found in right main bronchus.

heart and intrathoracic vessels between the distended lungs during the expiratory effort. It probably indicates an actual heart tamponade of brief duration with each respiratory cycle.[11] Expiration against a closed glottis will produce the roentgen signs of bilateral obstructive emphysema, but the picture will not be present at each respiratory effort, hence the two are easily differentiated by roentgenoscopy.[11] We have also observed these signs in the acute stage of tracheobronchitis of bacterial etiology, and have been unable to differentiate between the two conditions from the roentgen examination alone (Figs. 4 and 5).

The roentgen signs of atelectasis are the same whether the atelectasis is due to partial or complete obstruction of a bronchus, although they are usually more marked in the latter type. The lung distal to the point of obstruction shows a marked increase in density which is usually homogeneous in character. The mediastinum may shift to and fro slightly, but is displaced toward the affected side throughout both phases of respiration. The heart will be in the normal position only in those cases in which the lung fills with exudate, distal to the point of obstruction, forcing it to the midline. The picture would then be that of consolidation or empyema, and differentiation from roentgen signs is impossible. The diaphragm on the affected side is at a higher than normal level, and its motion is very limited. The ribs over the affected area remain in the expiratory position throughout respiration. A compensatory emphysema of the contralateral lung is nearly always present.

A small percentage of foreign bodies are unimpacted and move more or less freely from bronchus to trachea and back again. In these cases no marked abnormality is seen on roentgen examination but a persevering roentgenoscopic study usually shows fleeting changes, as the foreign body temporarily lodges in one or the other of the bronchi, and may lead to the diagnosis. This type of foreign body is the most difficult of all to diagnose correctly.

The roentgen signs found after the foreign body has been present for a long time differ in no wise from those found in pulmonary abscess or bronchiectasis of

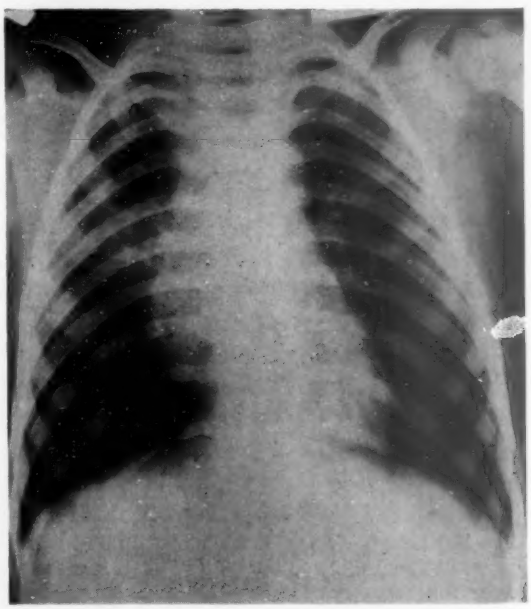

FIG. 5. Expiration. Same case as Figure 4. Note marked decrease in transverse cardiac diameter.

whatever etiology and will not be considered here.

The conditions causing signs and symptoms which are most often confused with the signs and symptoms of a foreign body in the respiratory tract are bronchopneumonia, unresolved pneumonia, chronic bronchitis, asthma, common croup, pulmonary tuberculosis, and acute laryngotracheobronchitis.

Roentgen examination should be made as early as possible in every case of suspected respiratory foreign body to confirm evidence received from the history and physical examination, or to clear up doubtful findings; to study the size, shape, nature and probable site of lodgment of the foreign body, thus shortening the bronchoscopy time; and finally, to make a permanent record which may be studied repeatedly. The earlier the diagnosis and the removal of a respiratory tract foreign body, the better will be the prognosis.

Nonopaque foreign bodies in the lower respiratory tract are most often misdiagnosed because of failure to think of the possibility of a foreign body, failure to make a thorough roentgenoscopic study, and improperly interpreted, poorly made roentgenograms. The possibility of nonopaque foreign body should always be borne in mind when examining children and infants for pulmonary disease. The roentgen examination should be repeated the following day or after a shorter interval if necessary in those cases where there is a positive history of the aspiration of a foreign body, and the initial examination is negative. In skillful hands and with proper care, a correct diagnosis can be made in nearly every case.

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CHYLOUS ASCITES

ROENTGENOLOGICAL OBSERVATIONS FROM A CASE IN INFANCY*

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CHYLOUS ascites may be found in either childhood or adult life. The following case showed an unusual feature which should aid in making the diagnosis of this condition by roentgenographic means.

REPORT OF CASE

C. S. was a white male, aged six days, who entered the hospital August 7, 1939, with symptoms of high intestinal obstruction since the first day of life. After supportive treatment, surgical exploration disclosed an incompletely rotated cecum, transduodenal bands, and a volvulus of the midgut. Reduction of the volvulus and severance of the duodenal bands afforded complete relief of symptoms. The baby was discharged home on the twelfth postoperative day. Subsequent to that time, the infant took his feedings well, gained weight, and appeared to be normal in every way, until six weeks of age, when the abdomen suddenly became distended. This was not accompanied by vomiting, refusal of food, diminution in stools or other signs of intestinal obstruction. On examination, the baby's general condition was good. The important findings were limited to the abdomen, which was diffusely and markedly distended. There was no visible peristalsis. Auscultation disclosed normal peristaltic activity. Percussion readily demonstrated a large amount of intra-abdominal fluid which could be

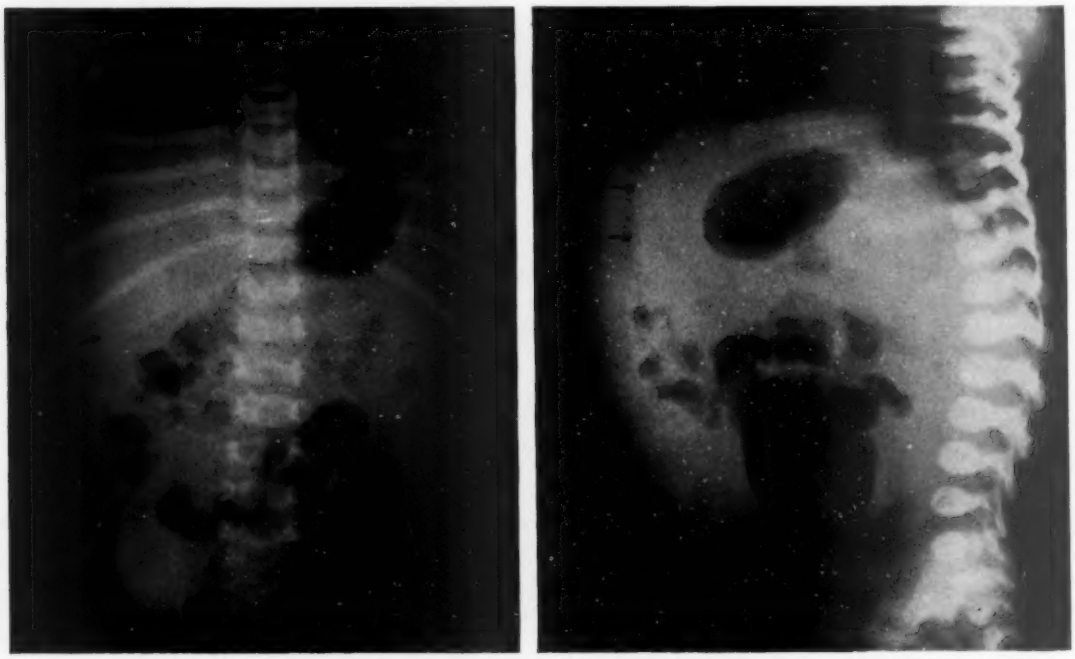

FIG. 1. Roentgenograms of a baby, aged six weeks, who was found to have chylous ascites at operation. There is abdominal distention and separation of intestinal loops by opaque areas having the appearance of free intra-abdominal fluid. The outlines of the liver (indicated by arrows) are visible, due to the increased radiability of the fluid which surrounds it. (The superior margin of the liver could be seen below the level of the diaphragm in an upright film which is not shown here.) These findings are in contrast to the usual ones in non-chylous ascites, in which abdominal fluid and liver have the same density.

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shifted as the baby was rolled from side to side. The child did not cry or have other evidence of pain. The old operative wound was well healed.

Roentgenograms (Fig. 1) showed the abdomen to be distended by fluid which separated several gas-filled loops of small and large intestine. The amount of gas in these loops was no more than is normally found in infants of this age. The liver was clearly delineated as a smooth, radiopaque structure surrounded by fluid which was relatively radiolucent. This contrast between the density of the liver shadow and that of the surrounding fluid was the only feature which differed from the usual appearance of ascites. There was no history of ingestion of a heavy metal which could have been deposited in the liver and thereby increase its radiopacity.

The possibility of fat-containing peritoneal fluid was discussed, but no exact preoperative diagnosis was made. Exploration was performed under ether anesthesia, and on opening the abdomen there gushed forth white fluid which had the appearance of thin uncurdled milk. An immediate smear of this showed no bacteria but there were many globules of fat. At a later analysis, it contained 9.5 per cent fat and had the characteristics of chyle. The source of the fluid could not be definitely ascertained. There were many adhesions between various loops of intestine and presumably one of these had exerted pressure across the bowel or mesentery in such a way that a small lacteal was obstructed and ruptured. Therefore, all adhesions which could be found were separated and the abdomen was closed. The child made a prompt recovery.

At the present writing, the baby is nine months of age, is in excellent health, and has no demonstrable peritoneal fluid or other abnormality. Roentgenological examination of the abdomen at this time shows no evidence of a pathological condition.

COMMENT

The increased radiability of fat as compared with other soft tissues of the body has long been known. This same characteristic apparently also holds true for liquids which contain large amounts of lipoid material. The radiopacity of ordinary ascitic fluid or peritoneal exudate is the same as that of the parenchymatous organs. Therefore, the visualization of solid abdominal organs as shadows which are surrounded by relatively radiolucent fluid suggests the presence of fat in the encompassing medium. Such visualization, in the absence of previous administration of a heavy metal, which might be stored in the reticuloendothelial system, justifies the diagnosis of chylous ascites.

OSTEOGENESIS IMPERFECTA*

REPORT OF TWELVE CASES

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OSTEOGENESIS imperfecta is a systemic disease of early life characterized by generalized osteoporosis, multiple fractures, relaxed ligaments, and sometimes blue sclera and deafness. Only 2 cases are known to have occurred in adult age.

Six subdivisions of this disease were described by different authors which, we believe, could be grouped conveniently into two divisions: osteogenesis imperfecta congenita and tarda.

The congenital form includes all cases which die *in utero* or are born with the disease. Knaggs[25] classified this group into (1) the fetal and (2) the infantile variety.

Osteogenesis imperfecta tarda includes those cases which were apparently normal at birth, and in which the disease occurred in the early years of life—usually the second. Many of this group have blue sclera and show a striking hereditary tendency. This group is often classified as (1) hereditary form with blue sclera, and (2) a non-hereditary form with or without a blue sclera. The former is usually referred to as "brittle bone and blue sclera," the latter as "fragilitas ossium."

Fairbank[14] mentioned the "honey-combed bone type" occurring in older children manifested by extreme fragility and cystic unossified areas of varying size in the bones. We had under observation 2 such cases (Cases VI and VII) and have serial roentgenograms of the bones. We found that these "honey-combed" areas occurred only after repeated fractures at the same site, and the areas of degeneration evidently followed bleeding into the bony structures. Both of these cases showed this honey-combed appearance on the femur simultaneously with the regular appearance of osteogenic imperfecta in other bones. One of them was born with fractures, while in the other the first fracture occurred at two years of age. We do not believe this is a different type of osteogenesis imperfecta, but a peculiar manifestation which is probably the effect of histamine in the bone liberated by incomplete fissure fractures as is believed in Kümmell's disease of the spine. Incomplete fissure fractures noted in both our cases revealed this honey-combed picture (Fig. 3).

Knaggs[25] describes a late type occurring in "middle life or old age"; this appeared in Ormerod's[30] and Hektoen's[19] reports. Ormerod's patient was born with fractures of both arms and was a victim of rickets in childhood, but later recovered and was able to live a normal life. At the age of forty, he gradually lost his body strength and his bones were so fragile that multiple fractures occurred from minor injuries. He died at the age of sixty-eight. His skeleton is in the Royal College of Surgeons Museum, London, England, and shows the typical changes of osteogenesis imperfecta with multiple fractures and extreme deformities of all ribs and long bones. We believe this case is not a different variety but a later flare up of a healed congenital type.

Hektoen's[19] case showed the characteristic findings of achondroplasia besides the multiple fractures, curving bones and 172 wormian bones of his skull. He was a forty-five year old dwarf with relatively short limbs which were wide and swollen at the epiphyseal portion of the bones. We believe this cannot be considered a true case of osteogenesis imperfecta.

Probably this classification of cases into two groups, congenital and tardive, is superfluous as is believed by Kaufmann[22] and Sumita.[34] We agree with them and be-

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lieve that all cases referred to as osteogenesis imperfecta congenita, tarda, hereditary and non-hereditary osteopsathyrosis, fragilitas ossium, brittle bone and blue sclera are all the same disease and, should be called simply osteogenesis imperfecta. One of our patients (Case VIII) was born with a united intrauterine fracture; 2 of them (Cases II and VI) had fractures at birth and undoubtedly these belong to the congenital group. Three acquired the first fractures in the second year of life (Cases IV, VII and X) and these belong to the tardive group. There are 2 cases in which classification would be difficult: Case I acquired her first fracture in the first week and Case V in the third month of life. They are the "connecting link" between the congenital and tardive groups indicating the impracticability of this classification.

The hereditary tendency in this disease has been proved. Eckman,[13] as early as 1788, reported hereditary fragility of bone which occurred in three generations. Spurway,[32] in 1896, had under observation four generations of a family in which 10 out of 13 members had multiple fractures. Conrad and Davenport[11] collected 35 families from the literature in which 2 or more members of each family had fragile bones. Key tabulated 19 families, totalling 477 members, of which 388 were descendants of affected parents; 241 had blue sclera; 146 multiple fractures and 56 were deaf. There are many interesting cases on record of families having affected members in the second, third and fourth generations. Joachim and Wasch's,[21] Conlon's[12] and Stobie's[33] families revealed affected members in five generations. On the other hand, there are more numerous reports in which heredity of the disease could not be traced. Colonna[10] in his series of 9 cases noticed a "striking absence of familial or hereditary tendency." Hein[18] reported a case of blue sclera and multiple fractures at birth and made a thorough investigation of 23 members of the family in which he was unable to find any presence of history of fragile bones or blue sclera. Terry's[35] statistics of collected cases show a hereditary origin in 9.8 per cent. Lippert[26] found it to be present in approximately 25 per cent of the cases recorded. A hereditary origin was present in 1 of our 12 cases (Case X); a brother had several fractures, from minor injuries, and died at the age of fifteen years from a skull fracture. Also, his maternal cousin had the same disease. The mother of Case III had short deformed legs, but no history of fractures could be traced in her case though her parents were first cousins. Hein[18] reports one similar case which was the offspring of first cousins.

Though microscopic studies are not numerous, most authors trace the imperfect bone formation to lack or improper function of the osteoblasts. Looser[27] believes that osteogenesis imperfecta is due to the "diminished function of the endosteal and periosteal osteoblasts which, however, are of normal structure." Bolton believes in a defective calcium metabolism caused by the dysfunction of thymus, parathyroid and hypotonicity of the sympathetics. Bauer[5] states that the histologic picture is characterized by a deficiency and dysfunction of the osteoblast. Weber[37] found the osseous system to consist of "fiber bone of inferior quality" because either the osteoblasts are absent or cannot produce the higher type shell bone. He found only the recent callus having normal rows of osteoblasts and osteoclasts. Knaggs[25] found the "absence of osteoblasts and formation of cartilage cells from the periosteum instead of osteoblasts" to be the most characteristic pathological findings. He believes there is an intrinsic and extrinsic factor—the intrinsic probably weakened vitality and the defect of certain mesoblasts or connective tissue cells in the embryo; the extrinsic cause is probably "the failure of an external influence normally brought to bear upon the cells which are destined to develop osteoblastic functions." He evidently means the lack of some hormone or enzyme. Axhausen[3] believes there is a deficiency of periosteal bone formation caused by the diminished function

of the osteoblasts. Sigowa[31] states the pathological process consists in a disproportion of the building up and breaking down activity leading to osteoporosis. Voorhoeve believes the etiology is "an inherited inferiority of the mesenchyme." Key[24]makes a similar statement—the underlying pathology is the "hereditary hypoplasia of the mesenchyme" and "all of the abnormalities seem to be due to defects in the development of some of the tissues which arise from the mesenchyme."

Hansen and his associates[17] found no disturbance in the acid-base equilibrium of body fluids and their experiment showed that both parathyroid extract and large doses of vitamin D produce a negative balance of phosphorus and calcium as they do in normal subjects so they are contraindicated. Hansen's [15,16] experiments show that one of the characteristic abnormalities in osteogenesis imperfecta is a deficiency in the retention of calcium and phosphorus under conditions which favor retention in a normal person. A similar deficiency in magnesium metabolism is suggestive, but his experiment was not conclusive. He also made an exhaustive postmortem biochemical study and found that the enzyme phosphatase was almost completely absent from the periosteal region of the bone, where it is abundant in normal bone, and also absent in the duodenal mucosa. Since this enzyme is greatly increased in fresh callus of normal bone[29] and in the blood in case of osteitis deformans, rickets and osteitis fibrosa cystica, it is evident that this enzyme is an important factor in the process of ossification.

The ash content of bone was found to be decreased first by Barker[4] as early as 1857. He found it to be 33.3 per cent; other investigators found it to vary between 33 per cent and the normal 60–66 per cent.

A peculiar "china blue" discoloration of the sclera present in some instances was observed and described first by Spurway.[32] Buchanan's[8] histologic study revealed a thinning of the cornea and sclera—the sclera being one-third as thick as normal, the cornea three-fifths normal. He also found a decrease in the total number of fibers, but could not demonstrate changes in the individual fibers. Von Ammon[2] proved by dissection that the blue sclera is considerably thinner than normal. On the other hand, Patterson found the thickness of the sclera to be normal and the size and number of fibers also normal in one case reported by Bronson.[7] Conlon[12] and Hermann and Fridenberg[20] believed that the increased transparency of the sclera was due to certain changes in the quality of the fibers and not to actual thinning. Both of them stated that a thin sclera would result in distention of the eyeball. Since the sclera is of mesenchymal origin and the frequency of this phenomenon appeared in 3 of our 11 cases, we believe that the pathology of osteogenesis imperfecta is of mesenchymal origin. The significance of blue sclera was overestimated by certain authors and was believed to indicate a separate entity among the idiopathic bone fragilities. It was believed that blue sclera was present in every case of "hereditary hypoplasia of mesenchyme" and "the characteristic feature of the heredity of blue sclera and brittle bones is that the condition is transmitted only by affected parents to their children. A generation is never skipped as is the case in hemophilia." Another author wrote, "It has been said that not all patients who have blue sclera possess bone fragility, but all cases presenting fragility of bones have blue sclera."

On the basis of our experience derived from the study of 12 cases, we cannot substantiate the above statements. Our Cases II and XII possessed a definite blue discoloration of the sclera and characteristic skeletal signs of "brittle bones" and had multiple fractures. Ligaments of Case XII were so relaxed that the patient was brought into the hospital with a diagnosis of dislocated hip, which was excluded by roentgen examination. The parents of both patients were examined for blue sclera and questioned carefully about family histories, which were definitely negative regarding

any kind of bone disease. Parents of Case II stated there had been no fractures in the family for three generations. In Case XII, the only known fracture, in three generations, was a multiple fracture of the maternal grandfather which occurred at the age of sixty-five when a tree fell on him. Fortunately, he was brought to the hospital for care and we still have his roentgenograms which show a normal bony structure and cortical thickness, no trace of previous fractures, deformities or osteoporosis. Family history of Case X shows a definite heredity form of this disease as one brother and a cousin from the maternal side had the same illness, but not even the slightest blue discoloration of the sclera was observed by several members of the staff at repeated examinations.

Transmission of this disease occurred through 2 unaffected males to the fourth generation in one of Lippert's[26] cases.

Patients affected with osteogenesis imperfecta are small, slender and delicately built. Cockayne[9] reported a family in which the affected members were markedly thin and light, compared to unaffected members of the family. The two affected men weighed about 90 pounds each. Weichman and Pool's[38] patient, a woman, weighed about 76 pounds. Eight of our 12 patients (66.7 per cent) were underdeveloped and underweight—3 of them approximately normal and 1 rather tall.

Bronson[7] first noticed the abnormalities of the head and described the affected members of two families. One had prominence of frontal and occipital bones, also palpable sutures, while the other family showed marked bulging of the frontal and supraorbital region.

Five of our patients (41.6 per cent) had heads larger than normal, one showed prominent frontal and occipital bones with rough palpable sutures, and one had marked prominence of the frontal and both temporal regions. The presence of wormian bones mentioned often in the literature was observed only once.

Mental development in this disease is usually normal. One of our patients was mentally deficient. She was unable to speak at the age of four and uttered only unintelligible sounds. Two were unusually bright, the others normal.

We have noticed an interesting finding in all of our cases: injection of the tonsils and pharynx, and positive throat cultures for staphylococci in 100 per cent. The literature does not reveal similar references, but this percentage seems too high for a simple coincidence. Probably a lowered resistance of the body affected by a systemic disease is responsible for this increased sensitivity of the upper respiratory tract.

Associated deafness was first reported by Adair-Dighton,[1] but Bronson,[7] Van der Hoeve and de Kleyn[36] showed that it is an integral part of this disease. The deafness is caused by involvement of the otic capsule which heals with sclerosis and produces a bony ankylosis of the stapediovestibular joint, impairing the transmitting system of sound waves to the internal ear. Van der Hoeve and de Kleyn demonstrated sclerosis of the os petrosa by roentgenograms. It is present in approximately 6 per cent of the cases reported, as estimated by Lippert,[26] and occurs usually in the third and fourth decades of life. None of our patients had this phenomenon.

Though extreme cases are diagnosed by first sight or by history of several fractures of trivial injury, the most important factor of diagnosis is a roentgenogram of the skeleton. There are definite roentgen signs of this disorder which are different in the newborn, infant and adolescent and also varied in different stages of the disease, but all similar in the generalized decalcification of the skeleton. The skull is only a fibrous bag plated here and there with a small bone plaque in the extreme form of a congenital case, as illustrated by Knaggs.[25] These cases are born dead or die within a few days.

The skulls of infants and adolescents are deformed, very often, to a certain degree. Seven of our 12 cases showed some changes on the roentgenogram: 5 had larger crani-

ums than normal, one disclosed numerous wormian bones, one showed marked prominence of the frontal and occipital bones, and one prominent frontal and temporal bones with rough sutures.

The long bones may be deformed by intrauterine fractures of the newborn, but the width of the shafts are proportional and even with the cortex so thin it is almost invisible. At the age of five or six, the shafts of involved bones become thinner, but the width of the epiphyses remains normal and this fact gives a peculiar elongated appearance to the bone on the roentgenogram though the actual length of the extremity remains normal. The affected bone, markedly bent by the malunion of repeated fractures, shows bizarre deformities, though displacement of the fragments is not rare at all. Subperiosteal fractures, with angulation of the fragments, are more common and sometimes these fractures heal so perfectly that no sign of an old fracture is traceable on the roentgenogram, other than the deformity.

Another interesting finding is the lateral displacement of the medullary canal at the place of deformity caused by repeated fractures. The explanation of this phenomenon is more new bone laid down at the concave side of the bent shaft than at the convex surface. Narrow triangular transverse decalcified, structureless areas extending into a variable distance to the shaft from the convex side of the bent bone are observed frequently (Fig. 3), and they often simulate an incomplete fracture. Looser[28] demonstrated that they are defects in the development of curvature. The bone trabeculation is scanty and coarse giving a more or less structureless appearance of the bone. In later years, the cortex becomes thicker, narrowing the medullary canal and giving a "brittle appearance" to the affected bone. We observed this phenomenon more in the tibia than the femur, or long bones of the upper extremities. The best illustration of this is Mucklow's case in Brailsford's[6] book.

The upper extremities are involved almost as often as the lower extremities; however, only 3 of our patients had no fractures of the upper extremities including the shoulder girdle. One patient (Case x) had a fracture of the scapula. We could demonstrate fractured ribs in only 4 cases, but they may have been present more frequently in earlier life in some of our cases. Even the small bones may be fractured as our Case x had a fractured toe.

The spine is very often affected; we observed it in 4 of our 12 cases. In mild cases scoliosis and kyphosis of varying degree occur, but in severe cases several of the vertebral bodies are compressed—3 of our cases showed this compression. It was very outstanding in Case XII; the lower two-thirds of the dorsal and the entire lumbar vertebrae were so narrow that the intervertebral discs, which showed no changes, were double and triple the height of vertebral bodies (Fig. 5). Similar changes in a lesser degree were observed in Cases I and VIII. Case IV showed a marked scoliosis of the lower dorsal and lumbar spine.

The pelvis is often involved showing decreased lateral diameter by pressure effect of the femora on the acetabulum. It was definitely present in 4 of our cases. Because of the poor calcium content of the skeleton, it is difficult to obtain a good roentgenogram of the severe cases.

Examination of the blood revealed red blood cells within normal limits—an average of 4,739,000 with hemoglobin 80 per cent (Sahli). White blood cells varied between 6,700 and 22,900—an average of 11,200 with 64.8 per cent neutrophiles, which could be due to upper respiratory infection present in all cases.

Blood calcium varied between 10.06 and 17.71 mg. per 100 cc.—an average of 12.79 mg. per 100 cc., indicating high values in 11 cases. Blood phosphorus varied between 2.8 and 5.4 mg. per 100 cc.—an average of 4.25 mg. per 100 cc., evidently within normal limits. These findings show that calcium was being thrown into the blood stream without an appreciable effect on the various factors which control calcium and phosphorus metabolism.

REPORT OF CASES

Case I (Hospital No. 44562). C. E., a white girl, aged three, was admitted on July 18, 1929. The child had a normal birth, breast fed until ten months of age, always had a good appetite, no bowel disturbances and no history of any child's disease. She sat alone at two and one-half years of age, but never walked or talked. Family history revealed seven brothers and sisters all healthy, and no similar disease was known in the family. Mother had two miscarriages, but there was no bone disease on either maternal or paternal side of the family.

Upon examination, we found an underdeveloped and undernourished white female infant weighing 16½ pounds. All long bones showed multiple deformities, marked bowing and shortening of actual length, ends were pointing toward gravity when lying down (Fig. 1). Mental condition was low and she uttered only unintelligible sounds. The head was box-shaped, sutures rough and uneven, tonsils were red and cryptic, and teeth fairly well developed. Roentgen examination showed extreme decalcification of all bones and numerous old united fractures involving all long bones and ribs (Fig. 2).

Laboratory Findings. Red blood cells 4,600,000; hemoglobin 75 per cent; white blood cells 8,000, 72 per cent neutrophiles; Wassermann negative; blood calcium 15.2 mg. per 100 cc.; blood phosphorus 3.9 mg. per 100 cc. Throat culture showed many staphylococci.

The patient showed no improvement, and died at the age of four from pneumonia.

Case II (Hospital No. 77197). E. L. A., well developed and well nourished white female child, aged fourteen months, was admitted October 20, 1934, with a recent fracture of left femur. The mother stated the child fractured this femur a few months before and the other at birth. Examination revealed the skin to be pale, frontal and parietal bones prominent, frontanel open and larger than normal. Sclera had pale bluish tint and teeth were decaying. Left thigh showed marked bulging at proximal third, foot everted and painful on motion.

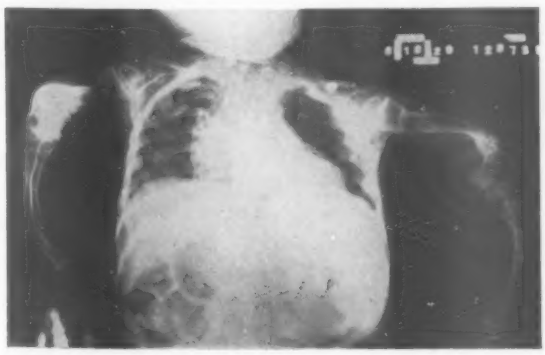

Fig. 1. Case I. Numerous fractures involving upper extremities, shoulder girdles and all ribs. Note deformed right humerus.

Fig. 2. Case I. Extreme deformity of lower extremities; note numerous subperiosteal fracture lines.

Roentgen examination revealed a recent fracture at proximal third of left femur, and old healed fractures of the shafts of both femora, humeri, and right radius. Both tibiae showed marked bowing. The entire skeleton showed marked decalcification, cortex of all bones very thin and the pelvis deformed and narrowed.

Laboratory Findings. Red blood cells 4,000,000; hemoglobin 75 per cent; white blood cells 10,000, neutrophiles 66 per cent; blood calcium 9.8 mg. per 100 cc.; blood phosphorus 4.6 mg. per 100 cc.; temperature 99.2° F. The pulse and respiration were normal on admission.

Family history was unimportant.

This patient returned several times with new fractures caused by trivial injuries, such as turning over in bed. The total number of fractures treated in this hospital was eight. At this time, present status of patient is not known.

CASE III (Hospital No. 44356). H. T., moderately developed, well nourished white boy, aged twenty-six months, was admitted on June 3, 1929, for a recent fracture of right femur. Mother stated that the boy was never able to walk, and his bones were so soft they have been broken several times. The patient's maternal grandparents were first cousins; the mother's lower limbs were underdeveloped.

Examination revealed all joints abnormally mobile, all extremities very thin and there was a prominence at the region of the lumbosacral junction. Roentgen examination showed the sacral canal to be open; old united fracture at middle third of right femur; a recent fracture at the lower third of left femur and tibia; skull had numerous stellate fractures on the left side, extending from the midline to base. All bones showed marked decalcification.

Laboratory Findings. Red blood cells 4,600,000; hemoglobin 85 per cent; white blood cells 22,900, 40 per cent neutrophiles; blood calcium 17.71 mg. per 100 cc.; blood phosphorus 4.42 mg. per 100 cc.; urine calcium 0.021 gm. in twenty-four hours; urine phosphorus 0.17 gm. in twenty-four hours. Throat culture showed gram positive cocci; staphylococci predominated; Wassermann negative.

Fractures were slow in healing and the patient returned several times for treatment of further fractures of left humerus, tibia, radius and ulna, and right femur. In 1933, we were notified by his local doctor that the patient continued to have fractures which healed in every instance.

CASE IV (Hospital No. 52911). E. L. K., fairly well developed, well nourished white girl, aged thirteen, was admitted on November 17, 1930. Present illness began when child was eighteen months old, the gums became swollen, teeth had abscesses around them, and six were removed at that time. At twenty-two months, she had a fracture of the left femur but apparently recovered and was able to walk without difficulty. Later, she had eight more fractures of the same leg, one of the right leg, and two of the right arm. The last fracture involved the left leg and occurred three years ago. Since that time the patient has not walked. Deformity of the spine took place during this time, and about four years ago the mother noticed a bowing of both tibiae. In addition to this, the child complained of "gas in stomach" and shortness of breath.

Patient was born at full term, delivery spontaneous, in good condition at birth and breast fed. Began cutting teeth at five months, sat up at six months, walked and talked at fourteen months. The child had measles and whooping cough. Family history unimportant.

On examination, head seemed to be large in proportion to body; teeth had a semi-transparent appearance; thorax was deformed; costal margins prominent and left side posteriorly bulging. The spine showed kyphosis, scoliosis and lordosis. Both tibiae had anterior bowing and right forearm lateral bowing.

Laboratory Findings. Red blood cells 5,210,000; hemoglobin 80 per cent; white blood cells 6,700, 52 per cent neutrophiles; blood calcium 14 mg. per 100 cc.; blood phosphorus 4.2 mg. per 100 cc. Throat culture showed many staphylococci.

Roentgen examination disclosed an extremely thin cortex of all bones; scoliosis and lordosis of the spine; vertebral bodies decalcified and thinned; pelvis retracted. Temperature, pulse, and respiration normal at admission.

CASE V (Hospital No. 84398). W. L. H., a girl, aged four, somewhat underdeveloped and undernourished, was admitted with a history of several old fractures of all extremities, the first occurring at three months of age. This was the fifth child; delivery was normal; sat up at six months, but was never able to walk. The mother had had antisyphilitic treatment, otherwise family history irrelevant. All other children in the family were normal.

Examination revealed scleras to have a bluish tint; both upper extremities were bowed and palpation disclosed thickening of old healed fractures; both clavicles were deformed from old fractures; elbows showed cubitus varus deformity; femora were bent, evidently from old fractures; knees showed genu valgum deformity and left forefoot was in adduction. Chest was pigeon shaped; spine showed marked right scoliosis and kyphosis.

Laboratory Findings. Red blood cells 4,400,000; hemoglobin 80 per cent; white blood cells 16,400, 74 per cent neutrophiles; Kline test negative; blood calcium 916 mg. per 100 cc.;

blood phosphorus 4.8 mg. per 100 cc.; throat culture showed staphylococci; temperature, pulse, and respiration normal at admission.

Case vi (Hospital No. 43290). R. A. G., well nourished, very small white boy, aged four, was admitted on March 10, 1929, with a fracture of the right femur which happened three weeks previously. The mother stated patient was born by breech extraction with fracture of both arms and legs. He was never able to walk. Had had sore throat very often. Family history irrelevant.

Examination showed head larger than normal; humeri and femora deformed; right femur very tender at site of deformity. Roentgen examination revealed a recent fracture with good callus formation at the proximal third of right femur and old united fractures at midshaft of humeri and left femur. Right humerus and both femora showed considerable bowing; pelvis marked contraction, but there were no fractured ribs.

Laboratory Findings. Red blood cells 4,200,000; hemoglobin 80 per cent; white blood cells 8,900, 62 per cent neutrophiles; blood calcium 10.06 mg. per 100 cc.; blood phosphorus 4.42 mg. per 100 cc.; throat culture showed many staphylococci. Temperature 99.4°F.; pulse, respiration, and blood pressure were normal at admission.

Fracture healed satisfactorily, with good callus formation, in six weeks. Patient fell out of bed on August 12, 1929, fracturing right femur just below lesser trochanter; this also healed without any difficulty. On February 18, 1930, patient again returned with a new fracture of lower third of left femur, and five months later another new one of middle third of right femur, both healing satisfactorily. On August 19, 1930, patient returned with fracture of left femur, upper third, and on March 15, 1931, fracture of middle third of same femur.

Patient was last seen on August 21, 1931, but showed no marked improvement. His present status is unknown.

Case vii (Hospital No. 53174). L. N., a white boy, aged nine, underdeveloped and undernourished, was admitted on December 4, 1930. He was born at full term, though labor was difficult. Breast fed, and teeth appeared at six or eight months. He started to walk when about two years of age, but his health generally and growth were always poor. Had several

Fig. 3. Case vii. Cystic (honeycomb) areas on anterior surface of deformed femur. Arrow: triangular structureless area extending into lateral two-thirds of shaft at the peak of bending, simulating incomplete subperiosteal fracture.

fractures of both legs by minor injuries and five months ago was in a car accident. Unable to walk since. Family history irrelevant.

Examination showed tonsils and pharynx very red; otherwise head, neck, and abdomen essentially normal, but chest was rather flat. Right femur showed marked anterior bowing and the left marked lateral bowing.

Roentgen examination revealed pronounced decalcification of all bones and previously mentioned deformity of femora with at least three old united fractures.

Laboratory Findings. Red blood cells 4,200,000; hemoglobin 80 per cent; white blood cells 10,600, 60 per cent neutrophiles; Wassermann reaction negative; blood calcium 13.33 mg. per 100 cc.; blood phosphorus 2.8 mg. per 100 cc.; urine showed calcium oxalate crystals; throat cultures showed many staphylococci.

The patient returned twice in 1931 and once in 1933 with recent fractures of the left femur; these healed without any difficulty. He was seen again in 1936 but had had no fracture in the preceding two and one-half years. Since roentgen examination showed several areas of cystic degeneration at the anterior surface of left femur (Fig. 3) no corrective operation of the bones was advised.

Case viii (Hospital No. 64972). L. B., a white boy, aged eight, poorly developed and undersized, was admitted on October 4, 1932.

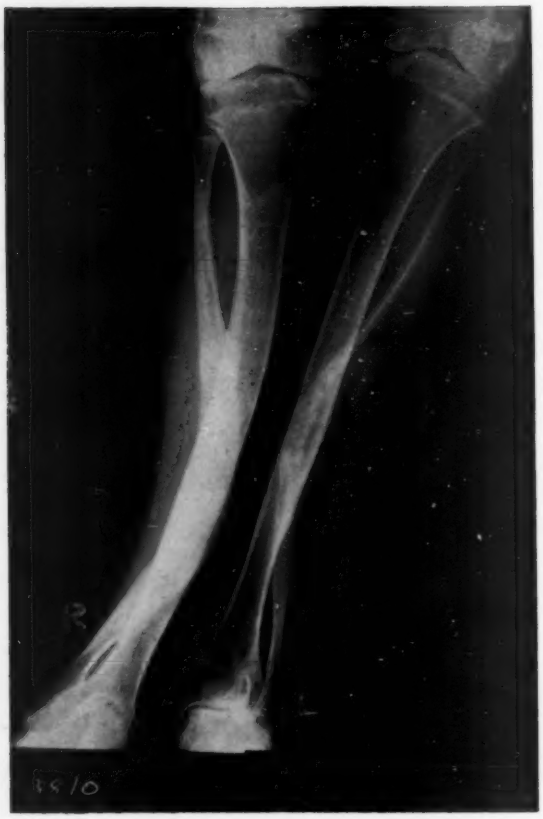

FIG. 4. Case x. Most common finding in the roentgenogram of osteogenesis imperfecta. Note thin cortex, deformed shafts.

His face looked about fifteen years old, but his body like that of a five year old child. Mentally, he was very bright and cooperative, but he had a speech defect like one caused by a large tongue. Patient was maldeveloped at birth, and had several fractures of practically all bones when he attempted to walk and use his arms. Family history irrelevant.

Examination showed head was large for size of body, with a prominent wide forehead and bulging temporal regions. Face was thin in proportion to cranium; scalp showed a bald spot of 3×3 cm. on the cranium, due to an old healed eczema. Scleras appeared normal; teeth were badly decayed with many missing; tonsils were hypertrophic and red; pigeon breast deformity with flaring of costal margins. The abdomen was flat and small in comparison to chest; tibiae were bowed anteriorly and appeared short. He was unable to walk without support. His right arm appeared to be normal, but left humerus, radius and ulna were bowed outward.

Roentgen examination revealed extreme decalcification of all bones with several old united fractures, resulting in extreme bowing of all long bones.

Laboratory Findings. Red blood cells 4,800,000; hemoglobin 80 per cent; white blood cells 10,200, 76 per cent neutrophiles; Wassermann reaction and urinalysis negative; blood calcium 13.3 mg. per 100 cc.; blood phosphorus 4.2 mg. per 100 cc.; throat culture showed many staphylococci; urine calcium 0.01 gm. in twenty-four hours, and urine phosphorus 0.12 gm. in twenty-four hours.

CASE IX (Hospital No. 80636). J. W. A., well developed and nourished white boy, aged four, was admitted on May 20, 1935, with a recent fracture of left tibiae; he had had five previous fractures and all united without any difficulty. Family and past history otherwise unimportant.

Scleras were normal and roentgen examination showed marked decalcification of all bones with old united fractures of both lower extremities and an incomplete transverse fracture at the midshaft of the left tibia with anterior bowing.

Fracture healed normally but he was admitted one month later for a fracture of both tibiae, and three months later returned with a fractured clavicle, all healing satisfactorily. A short time later a tonsillectomy was done because of repeated tonsillitis.

Laboratory Findings. Red blood cells 4,680,000; hemoglobin 80 per cent; white blood cells 10,400, 76 per cent neutrophiles; blood calcium 10.2 mg. per 100 cc.; blood phosphorus 5.2 mg. per 100 cc.; urine showed triple phosphate crystals.

He is, at this time, returning with new fractures, at least twenty-six in number, including femur, tibiae and clavicle. It is interesting to note that one of his fractures occurred when he was walking and one when he was turning over in bed.

CASE X (Hospital No. 65488). A. H., a well developed and fairly well nourished white boy, aged eleven was admitted on November 7, 1932, for a recent fracture of left tibia. Patient was born at full term, breast fed, had whooping cough, diphtheria and chicken pox. At two years of age, he had a broken leg and from this time had twenty fractures, including femora, tibiae, clavicle, scapula, ribs, great toe, humerus, radius, and ulna. He stated his bones

would fracture while he was walking or supporting himself on crutches. Fractures occurred without any trauma. This fracture occurred spontaneously when patient was resting on his crutches; he had a sudden pain just below left knee and could feel the bones grind together.

A brother and cousin on his mother's side had this same kind of bone disorder. The brother died with a fractured skull at fifteen years of age. When the patient was admitted, he was a sixth grade pupil and stated he made fair grades in school. He seemed intelligent and was very cooperative.

Examination revealed a clear sclera without any trace of bluish tint. Head, neck and chest were negative; tonsils enlarged. Upper extremities appeared underdeveloped; both femora showed lateral bowing, callus of former fractures was palpable. Muscles of both lower extremities were underdeveloped.

Roentgen examination showed marked decalcification of all bones, outer plate of skull was very thin; shafts of lower extremities were markedly decreased in width and the cortex of all bones was thin. Previously mentioned deformities and several old united fractures were also seen (Fig. 4).

Laboratory Findings. Red blood cells 5,460,000; hemoglobin 85 per cent; white blood cells 7,900, 70 per cent neutrophiles; Wassermann reaction negative; blood calcium 12.9 mg. per 100 cc.; blood phosphorus 2.8 mg. per 100 cc.; urine showed triple phosphate crystals and throat culture many staphylococci.

Fracture healed without any difficulty, but the patient returned several times with new fractures, at least twenty-nine in number. He was readmitted for corrective surgery, osteotomy of left tibia was done and bone graft applied. Several months later, right leg was corrected and shortened to length of left. Excellent results were obtained and both legs are now straight. Patient was last seen September 30, 1939, and had no complaints.

Fig. 5. Case xi. Bodies of lower dorsal and lumbar vertebrae are extremely narrow from compressed fractures; intervertebral discs are larger than compressed bodies.

Case xi (Hospital No. 100787). O. M., a poorly developed female, aged six, was admitted March 17, 1939. Her mother was Indian and the father Caucasian. A few days after birth, the mother noticed the lower extremities were deformed; the hips not well developed and the bones having the appearance of being "mashed together." The child was a full term baby and delivery was normal. Dentition occurred at two years of age, speech at three years, but patient never walked. The mother stated the child caught cold easily and frequently. There was no family history of bone diseases or other familial diseases.

Physical examination showed a small, poorly nourished child in no acute distress. The entire skeleton was apparently deformed; the head large in comparison to remainder of body and long arms with marked cubitus varus on the left and moderate on the right. The spine showed moderate kyphosis, and both upper thighs marked lateral bowing.

Roentgen examination revealed the skeleton to have generalized decalcification; all the thoracic and lumbar vertebral bodies compressed, many of them wedge-shaped; intervertebral discs, though normal in appearance, were wider than the compressed bodies (Fig. 5). Upper third of both femoral shafts had marked lateral bowing and coxa vara deformities and there was compression of the pelvis at the level of the acetabula.

Laboratory Findings. Red blood cells 4,090,000; hemoglobin 80 per cent; white blood cells 12,500, 60 per cent neutrophiles; urine negative; Wassermann reaction negative, blood cholesterol 130.3 mg. per 100 cc.; blood calcium 10.8 mg. per 100 cc.; blood phosphorus 4.6 mg. per 100 cc.; basal metabolic rate plus 18 per cent.

The therapy consisted of cod-liver oil, maltine, and dietary advice. Patient returned six months later, slightly improved and able to walk with crutches.

CASE XII (Hospital No. 84303). G. M. C., a white female, aged eighteen months, was brought to the hospital on November 18, 1939, with a diagnosis of congenital dislocation of both hips—based on overmobility of joints. The mother stated the child was normal at birth, though small in size; could sit alone, but never stood up. Family history was irrelevant; there are four other children all normally developed.

Examination revealed an underdeveloped and undernourished white girl with no visible sign of any abnormality except outstanding blue sclera; throat and tonsils were injected.

Roentgen examination of entire skeleton disclosed a marked generalized osteoporosis with thin cortex; old healed fracture lines, without any deformity on both humeri, femora, and tibiae, but no dislocation of hips.

A diagnosis of osteogenesis imperfecta was made solely on roentgen findings without seeing the child. Patient was not admitted at that time, but the mother was instructed to handle her very carefully. Within a month she was admitted with a recent fracture of left femur, occurring when she turned over in bed. Fracture healed normally within three weeks. A careful history was taken from the mother, but no evidence of hereditary transmission was disclosed. She did not know when the old fractures, shown on roentgenograms, occurred, but noticed a shortening of one leg about six months previous to admission, however did nothing about it. The baby cried when extremities were touched.

Laboratory Findings. Red blood cells 4,200,000; hemoglobin 80 per cent; white blood cells 12,000; 76 per cent neutrophiles; Wassermann reaction negative; blood calcium 12.8 mg. per 100 cc.; blood phosphorus 2.7 mg. per 100 cc.; urine showed triple phosphate crystals, and throat culture showed many staphylococci.

SUMMARY

Twelve cases of osteogenesis imperfecta are reported.

The roentgen findings are especially discussed; important historical, clinical and pathological data recorded in the international medical literature are reviewed.

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CONGENITAL HYDROCEPHALUS

REPORT OF TWO CASES

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THE occurrence of congenital hydrocephalus in the practice of obstetrics is fortunately not common but when present it may prove to be a serious complication if not diagnosed early. In the majority of cases reported in the literature its presence is usually detected only after arrest of labor or rupture of the uterus. The roentgenographic study of the patient at term in recent years has offered a means by which, in questionable cases, the presence of hydrocephalus may be confirmed before the onset of labor. The 2 cases presented in this report were diagnosed by the pelviocephalometric method of Ball. One case was examined three weeks prior to delivery, the other, only after attempted forceps extraction.

CASE 1. The patient, white, primipara, aged nineteen, in the ninth month of pregnancy, was found to have enlargement of the uterus out of proportion to the period of gestation. The presence of hydramnios or twins was suspected; the latter was felt to be more likely because it was thought that two fetal hearts could be heard. Roentgen examination revealed the presence of a single fetus in utero with the head presenting but riding above the superior strait. The fetal cranium measured 50 cm. and had a volume capacity of 2,010 ml. A diagnosis of congenital hydrocephalus was made (Fig. 1). It was decided to permit the patient to go into labor. Three weeks later the patient was ad-

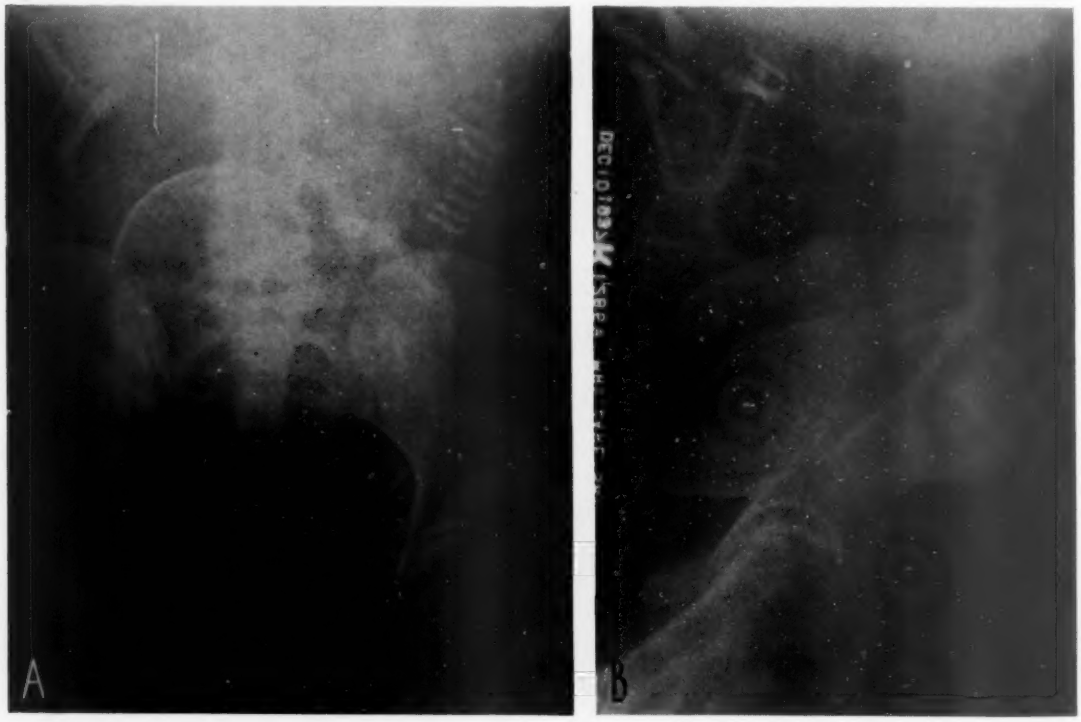

FIG. 1. Case 1. Anteroposterior, *A*, and lateral, *B*, roentgenograms show the marked enlargement of the fetal skull with thinning of the tables. The head is resting just above the superior strait. The disproportion is quite obvious.

mitted to the hospital in active labor. The cervix was dilated almost completely and the head by rectal examination had descended to just above the level of the ischial spines. After the usual vaginal preparation a Kelly forceps was introduced into the posterior fontanel and a flow of blood-tinged fluid (approximately 800 cc.) drained off. Immediately thereafter the head descended to the perineum, and, after a lateral episiotomy, was delivered with ease.

On examination of the fetus the cranial bones were found to be thinned and overlapping. The entire head was elongated, more particularly posteriorly (Fig. 2). The calvarium was then split along the sagittal plane, revealing a large cranial cavity (Fig. 3) and an attenuated cerebrum which occupied only the anterior portion. The brain was removed and sectioned. The lateral ventricles were found to be about eight times normal size. The brain tissue was consideraby thinned, particularly over the lateral ventricle.

Case II. The patient, white, primipara, aged eighteen, was admitted to the hospital following thirty hours of labor. Shortly after admission the membranes ruptured and the cervix was found to be almost fully dilated. The head could be felt just dipping into the brim of the pelvis and an effort was made to apply high forceps. Two unsuccessful applications discouraged the operator and he referred the patient for a roentgen examination. This examination (Fig. 4) of the pelvis showed a single fetus in utero with a tremendous head, attempting to mold into the superior strait. The perimeter measured 52 cm. and had a volume capacity of about 2,105 ml. Although the presence of hydrocephalus had been unsuspected clinically, the diagnosis was established by the roentgen appearance of the fetal head characterized by tremendous increase in the perimeter and thinning of the calvarium.

Fig. 2. Case I. Photograph shows the increase in size and elongation of the fetal head immediately after delivery.

Fig. 3. Case I. The skull was opened along the sagittal suture and the brain, as shown in this illustration, was found to be collapsed. The large cranial cavity is evident.

It was thought advisable, because of the possibility of a ruptured uterus, to perform a caesarean section. On opening the abdomen there was no evidence of free blood in the peritoneal cavity. A low section of the uterus was done and the fetus delivered. It presented a markedly elongated head. The baby lived for three days. No postmortem was obtained. The mother made an uneventful recovery.

The incidence of marked hydrocephalus is reported to be about 1:3,000. Milder forms are more often encountered. Congenital hydrocephalus is characterized by

FIG. 4. Case 11. Anteroposterior, *A*, and lateral, *B*, roentgenograms show the large fetal skull attempting to mold into the inlet. This examination was made after two unsuccessful forceps applications.

an abnormal increase in the size of the fetal cranium and is the result of an excessive accumulation of spinal fluid within the ventricles or in the subarachnoid space. The head may reach a circumference as great as 80 cm. and contain as much as 2 quarts of fluid. There is marked thinning of the cranial bones with impairment of ossification. The brain tissue is partially destroyed due to the increased pressure.

There are three points at which obstruction may occur to prevent the normal passage of the fluid: the aqueduct of Sylvius, the foramen of Magendie, and the third ventricle (Boyd). Because of its length and narrow lumen the aqueduct is considered the weakest point. Dandy and Blackfan produced hydrocephalus in dogs by placing a capsule in the aqueduct of Sylvius. No single definite factor has been shown to be the cause of congenital hydrocephalus. Syphilis has been suggested as an etiological agent, but a study of the published cases has not borne out this contention.

In cases presenting a greatly enlarged abdomen the differential diagnosis includes hydrocephalus, multiple pregnancy, tumor, abnormally high pregnant uterus due to marked pelvic contraction, or hydramnios. It is found that often when hydramnios occurs there will be an associated fetal anomaly (Falls). Careful clinical examinations in hydrocephalus disclose the presence of an enlarged head with widened sultures and fontanels, presenting a peculiar crackling sensation and fluctuation. The greater the size of the head, the greater the tendency toward breech presentation (Davis), in the event of which abdominal palpation should confirm the presence of the enlarged head in the fundus. On lower abdominal palpation the presenting head may be felt as a large movable body isolated over the superior strait. On vaginal examination, following dilation of the cervix, one may detect the fluctuation through the separated sutures and fontanels. In cases of marked hydramnios, however, the large cranium may be overlooked. According to Schumann, the presence of a fetal pulse rate which has dropped sharply suggests that the fetus has been undergoing dangerous pressure, either compression of the skull or pressure upon the cord.

Modern roentgenographic technique enables the roentgenologist to measure accurately the size of the fetal cranium. According to the Ball standards the normal volume capacity of the head should not greatly exceed 700 ml. Cases of slight hydrocephalus have a capacity of about 900 ml., and marked hydrocephalus, 1,050 ml. or over. The roentgenograms reveal the presence of a large head with separated sutures and fontanels and somewhat translucent cranial bones. A roentgen examination is indicated in all suspicious cases of hydramnios accompanied by failing fetal pulse and lively fetal movements (Granzow).

The accepted form of treatment in marked hydrocephalus is to disregard the child entirely because of the many associated anomalies, such as spina bifida, anophthalmus, mental abnormalities, and also the damaging effect in delivery to the mother. Most obstetricians advocate the use of a trocar to rupture the dura and allow the cerebrospinal fluid to drain off. A certain few cases will deliver spontaneously due either to a previous rupture of a fontanel or excessive molding of the head. It is unsafe, however, to rely on nature's efforts to deliver the child for there is constant danger of rupture of the uterus.

SUMMARY

In view of the fact that early diagnosis assures a low mortality rate it is expedient to be on the alert for the possibility of congenital hydrocephalus in abnormal pregnancies. Careful clinical examination accompanied by roentgenographic examination of all suspicious cases assures early diagnosis, thus rendering the treatment elective.

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COBRA VENOM IN THE RELIEF OF PAIN DUE TO CANCER*

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RECENTLY the use of cobra venom for the relief of pain was suggested by Monaelesser and Taguet[35] who observed complete relief of severe neuritic pain in a leper bitten by a tarantula. This led to a study of the neurotoxic properties of venoms in an effort to discover an effective agent for the relief of pain. Cobra venom was decided upon because it seemed richest in neurotoxins.[14,24]

CHEMICAL PROPERTIES

Venom, as collected from the cobra, is a clear, straw colored fluid.[1] When dried the solid matter is deposited as scales, approximately 200–370 mg. of the solid being obtained from each ejaculation.[1,3] In this form its potency remains constant for years.[3] In solution the drug deteriorates more rapidly.

Among other constituents, cobra venom contains albumin, pseudoglobulin, and a glucoside belonging to the saponin group.[42] In vitro it digests fibrin and gelatine[42] which may explain the decreases in tumor size seen in patients receiving the drug.[19,22,44]

PHYSIOLOGICAL PROPERTIES

It is not within the province of this communication to discuss all that is known of the pharmacodynamics of cobra venom. This information may be obtained in detail from excellent reports by Feldberg and Kellaway,[10,11,12,13,17] Guerrini,[15] Cicardo,[5] Macht,[27,28,29,30,32] Koressios,[22] Körbler,[21] and others.[2,4,7,8,9,16,18,20,23,24,25,26,34,35,36,37,38,39,40,41,45]

The outstanding physiological characteristics of venom may be briefly summarized as follows:

(a) In monkeys, early investigators described irreversible cellular changes in the brain and cord following intrathecal injections of the drug.[25]

(b) Recently Feldberg and Kellaway[10,11,12] and others demonstrated that injections of cobra venom were followed by the liberation of tissue histamine.

(c) An enzyme, lecithinase, has been identified in cobra venom. This enzyme, acting upon lecithin, breaks it down to form lysocithin.[12,22,35] When used in perfusion experiments the latter produces definite degenerative tissue changes.[15,37]

The exact mode of action of cobra venom is unknown. Monaelesser and Taguet[35] recently suggested that its pain-relieving properties were due to the presence of lecithinase in the drug. Lecithinase, having a marked affinity for lecithin, might alter nerve conductivity by affecting the lecithin normally abundant in nervous tissue. This hypothesis has been substantiated by Cicardo[5] who found that the threshold of nerves to stimuli rose in the presence of cobra venom. Of added interest is the fact that the threshold of sensory nerves was affected before that of motor nerves.

We have observed the relief of pain due to lesions in the spinal cord and thalamus following cobra venom injections. Pain of this type being central in origin, one might suggest that the beneficial effects of the drug are due to its action upon the central nervous system. In Macht's opinion[29] both cobra venom and morphine act upon the subcortical brain centers, the chief difference being that morphine acts quickly and for a brief period, whereas cobra venom acts slowly over a longer interval.

The local reactions to therapeutic injections of cobra venom are negligible.[19,22,24,25] There have been reports of an inflammatory reaction in the injected area which simu-

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lates fatal snake bite. In man a fatal snake bite[19] is rapidly followed by decreased local sensitivity. Anesthesia slowly extends throughout the entire body until weariness and sleepiness overcome the patients. Death ensues as the result of respiratory failure.

What happens to cobra venom injected in man is unknown. We believe that a part, at least, is excreted into the gastrointestinal tract because we have observed abdominal cramps, diarrhea, and a bad taste in the mouth in some of our patients receiving the drug. It is fair to state, however, that part of these symptoms could be the result of a histamine reaction in the gastrointestinal tract.[6]

DOSAGE

The drug is supplied for clinical use in 1 cc. ampules containing 10 mouse units,[32] approximately equivalent to 0.1 mg. of the dried venom.* One mouse unit equals the amount of cobra venom which kills a 20–22 gram mouse in twenty hours when injected intraperitoneally.

The hemolytic properties of the older preparations seem to have been eliminated from the preparations now available for clinical use. Indeed, we have observed improvement in red cell counts and hemoglobin during the period of treatment. In addition we have found nothing to suggest renal damage in the urine of these individuals.

As a rule the patient is given 0.5 cc. of the drug (5 mouse units) intramuscularly for the first dose. Whereas some authors[22,38] have advocated injecting the venom into or around the tumor, we have found ordinary intramuscular administrations to be equally effective. If no untoward reactions develop, such as abdominal cramps or diarrhea, the patient is given 1 cc. on the second day. Occasionally the pain becomes worse after the first few injections. This is no contraindication to further use of the drug as the pain frequently disappears rapidly thereafter. The drug is administered daily in 1 to 1.5 cc. doses until the pain is completely relieved. In our experience this occurs by the time the fifth injection has been given. Occasionally lasting relief may follow the first few doses of the venom. In one instance the desired relief was not attained until the eighteenth day. Relief of pain having been obtained, the interval between injection is gradually lengthened until a maintenance dose is established.[19]

Determining the maintenance dose of cobra venom necessitates "feeling one's way" much as one does in establishing the maintenance of digitalis in persons with heart disease. We have frequently kept patients free of symptoms with one to three injections a week. Indeed one patient has learned to give herself injections of cobra venom just as diabetics administer their own insulin.[45]

Some authors have advocated using much larger doses,[22,24,43] giving six to eight times the amount referred to above. Starting with 3 cc. instead of 0.5 cc., these men rapidly increase the dose until the patient receives up to 8 cc. daily.[22] Nose-bleeds, psychic upsets, and gastrointestinal disturbances are frequently associated with such large doses. Though the lethal dose of cobra venom for man is estimated[1,22,24] at 15–20 mg., we have hesitated to follow the massive dose technique. Until more is known of the toxic effects of the drug, we prefer to err on the conservative side.

UNTOWARD REACTIONS

Untoward reactions to the intramuscular injection of cobra venom have been few in our experience. Local inflammation in the injected area, temporary exacerbations of pain, abdominal cramps, and diarrhea developed in a few of our patients. In no instance was the reaction severe enough to warrant discontinuing the drug. Mild mental confusion and epistaxis have been reported by those using larger quantities than we employed. There is one patient on record who developed temporary radial palsy following the injection of large doses of the venom.

* We are indebted to Hynson, Westcott, and Dunning for our supply of cobra venom.

TABLE I

Date	Name	Total No. of Cases	Definite Relief	Moderate Relief	Little or No Relief	Remarks
1933	Monaelesser and Taguet[35]	115	"Nearly always improved"			
1934	Körbler[21]	2	100%			
1936	Kirschen[19]	23	18%	21.7%	61%	
1936	Macht[32]	105	36.2%	28.6%	35.2%	Selected series
1938	Macht[33]	185	70%		10%	Data incomplete
1939	Rutherford[43]	17	50%	30%	20%	Probably a selected series
1939	Present series	21	53%	28%	19%	

INDICATIONS AND CONTRAINDICATIONS

Since it is impossible to predict who will and who will not be benefited by the venom,[19,22] we have never refused to administer it to a patient suffering from severe and constant pain. In our experience, the prolonged use of small doses of the drug (four months) has not been followed by toxic symptoms or evidence of addiction.

Less is known concerning the contraindications to cobra venom. Based upon animal experiments, it has been empirically stated that the drug should not be used in patients with severe liver or kidney damage and in patients with psychic disturbances.[19]

RESULTS

Some of the results reported by others who have used the venom for pain are summarized in Table I.

We have treated 21 patients with pain due to cancer with cobra venom. Of this number, 11 had an excellent response (80 per cent relief of pain or better). Six patients had moderate relief of pain (50 to 80 per cent relief). Four patients had little or no response to the drug.

The following case summaries are presented as they illustrate the type of patient treated and the result obtained. In addition they demonstrate the doses employed and the rate at which the drug was administered.

CASE I. *Excellent Result.* Male, aged seventy, complained of pain along the distribution of both sciatic nerves secondary to a carcinoma of the rectosigmoid. Three grains of morphine daily did not control the pain. Cobra venom was employed as follows:

1st day	0.5 cc.	Moderate relief
2nd day	1.0 cc.	Still further relief
3rd day	1.0 cc.	Morphine no longer needed
4th day	sterile hypo.	Pain worse
5th day	1.0 cc.	Almost complete relief
6th day	1.0 cc.	Complete relief

Daily injections continued to keep the patient comfortable. When last heard from the drug had been stopped by the family physician who feared its constant use.

CASE II. *Moderate Relief.* Male, aged thirteen, complained of pain in the left thigh due to spinal cord metastasis from a cerebellar medulloblastoma. Cobra venom employed as follows:

1st day	0.5 cc.	Pain worse
2nd day	0.75 cc.	Pain worse
3rd day	1.0 cc.	Slight relief
5th day	1.0 cc.	Slight relief
6th day	1.0 cc.	Moderate relief
8th day	1.0 cc.	Pain slight now
9th day	1.0 cc.	Pain unchanged
12th day	1.0 cc.	Definite improvement
15th day	1.0 cc.	Continued improvement

One injection every two weeks kept this patient comfortable.

SUMMARY

Cobra venom has been used successfully in 50 to 70 per cent of the patients in whom it has been injected for the relief of pain. While it is too early to assign cobra venom to a permanent place as an analgesic agent, the evidence suggests that it may prove to be of considerable value in the treatment of intractable pain.

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THE ADVANTAGES OF ROENTGENOSCOPY AND ROENTGENOSCOPIC "SPOT" ROENTGENOGRAMS IN THE DIAGNOSIS OF EARLY PULMONARY TUBERCULOSIS*

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THE statement that the roentgenoscopic examination is as efficient or more efficient in finding early pulmonary lesions than the roentgenogram taken in the posteroanterior exposure either with single or stereoscopic films will be met with considerable skepticism. The work of Fellows and Ordway,[1,2] Reid,[6,7] and Hetherington and Flahiff,[4] indicates that roentgenoscopic examination is far superior to the physical examination in finding tuberculous lesions. In comparing roentgenoscopy with roentgenography, Fellows and Ordway[3] found that 87 per cent of the lesions discovered by the roentgengram were visible by roentgenoscopy. They indicate that their examinations were made under some definite physical handicaps, and we quote: "For instance, when the physical examination is finished the physician takes the person being examined into an adjoining fluoroscopic room and within a minute or so begins the fluoroscopic examination. We do not have time to wait for perfect accommodation in the dark room because of the pressure of the work, and yet we have not found it feasible to have teams of particularly able examiners do the fluoroscopic work exclusively." The lack of proper eye accommodation, plus the personal factor of skill and training, probably offers sufficient reason why 13 per cent of the infiltrations found on the film were not discovered by roentgenoscopy. Fellows and Ordway do not indicate the type of lesion that escaped detection on roentgenoscopy or whether in any instance lesions were found on roentgenoscopy that were not discovered on the roentgenogram. In our experience neither method is capable of finding all the existing lesions or abnormalities.

Hetherington and Flahiff,[4] not having the advantage of the Patterson "B" type screen, state in their conclusions, "Tuberculous infiltration limited to the apex of the lung above the clavicle is seldom recognizable by fluoroscopic examination."

Skepticism regarding the value of the roentgenoscope in finding early tuberculous lesions is further emphasized by a questionnaire sent to twelve roentgenologists by Pohle, Paul and Beatty.[5] The replies received indicated that the opinion is generally held that the roentgenoscope cannot detect tuberculous lesions as early as the single or stereoscopic film, and that a large percentage of the lesions visible on the film would not be found by the roentgenoscopic examination. The low esteem in which the roentgenoscopic method of examination is generally held, compared to roentgenography, offers an explanation of why this method of study has been slow to be accepted or its potentialities developed.

DEVELOPMENT OF ROENTGENOSCOPIC METHODS

Beginning in 1933, all students attending the University of Wisconsin and positive to the Mantoux test have had made at the time of enrollment a single posteroanterior film of their chests. The importance of roentgen re-examination[8] of the infected individuals at regular intervals was appreciated, but the question of expense was also a necessary consideration. Though much skepticism was expressed as to the value of roentgenoscopy in finding the minimal tu-

* From the Department of Student Health, University of Wisconsin. This work was made possible by grants from the National Tuberculosis Association and the Wisconsin Alumni Research Foundation.

berculous lesion, a machine was purchased in 1934, and roentgenoscopic examinations of all infected students have been made at intervals of from three to twenty months. In the five school years from 1934 to 1938, inclusive, a total of 43 active cases of tuberculosis have developed subsequent to enrollment. Excluding 3 cases of pleurisy with effusion, 37 of 40 cases were found by roentgenoscopic examination while in the minimal stage. During this five year period in the routine of doing daily roentgenoscopic examinations and making comparisons with single and stereoscopic films, the conviction arose that certain lesions of the lungs, notably those at the extreme apices and clavicular areas, did not show at all or to the same advantage on the film as on the fluoroscopic screen.

To better compare roentgenoscopy with the single posteroanterior film, a group of 423 consecutive cases, 228 men and 195 women, received in the fall of 1938 the advantage of both methods of examination. The results of this study are shown in Table 1. In this particular group, no apical or clavicular infiltrate visible on the film escaped detection by roentgenoscopic examination, and in 5 instances lesions not visible in these areas on the routine film were found by roentgenoscopy. In comparing the two methods of examination (Table 1) it is evident that both methods fail to find all lesions or abnormalities. On the basis of the 423 examinations made, the single film in this study was 91 per cent efficient compared to 95.7 per cent for roentgenoscopy. From further analysis of the table it will be noted that 293 of the 423 cases, or approximately 70 per cent, were negative by both examinations. Approximately the same number of calcifications were found by both methods. The film has a distinct advantage when the calcifications are small and in the hila, for in 1 case of every 4 these small calcifications were not found by roentgenoscopic examination. The area about the hilum is also difficult to examine with the roentgenoscope for a fuzzy hilar shadow fades so imperceptibly

TABLE I

A COMPARISON OF ROENTGENOGRAPHIC AND ROENTGENOSCOPIC EXAMINATIONS MALES AND FEMALES

Description	Found by Both Methods	Roentgenogram		Roentgenoscopy	
		Found	Missed	Found	Missed
Negative	293	293	0	293	0
Calcium in the lungs and in the tracheobronchial lymph nodes	27	24	3	26	1
Calcium in tracheobronchial nodes only	36	26	10*	26	10
Calcium in lungs	30	24	6	25	5
Hilar lymphadenopathy	2	2	0	0	2
Apical and clavicular infiltrates	11	6	5	11	0
Other infiltrates	6	5	1	6	0
Apical pleuritis	14	2	12	14	0
Azygos lobe	3	3	0	3	0
Thickened interlobar fissure	1	0	1	1	0
TOTALS	423	385 91%	38 9%	405 96%	18 4%

In 13 instances blood vessels were mistaken for Ghon tubercles on the film. Large adhesions to the diaphragm were noted in only 2 instances on the film, compared to 12 on roentgenoscopy. Abnormalities of the bones were noted in 10 instances on the films compared to only 4 on roentgenoscopy.

* Three were not visible on film because of position directly posterior to heart.

into the lung structure that small enlargements or abnormalities are sometimes difficult to determine.

A small percentage of individuals are not eligible for roentgenoscopic examinations of their lungs because of their large size. Where good penetration is not possible, an entirely satisfactory examination cannot be made, and the examiner must appreciate his limitations in examining these thick-chested individuals. Among students approximately 2 per cent are not examined by roentgenoscopy on this account.

Because the position of the individual is constantly being changed during the examination, roentgenoscopy has a definite advantage over the roentgenogram in making visible small infiltrates at the extreme apices, in the clavicular areas, and at the lung periphery. This is true because small infiltrates in these areas are frequently covered by the bony framework of the chest. By maneuvering the patient in many positions these infiltrates are rather easily brought into view.

Inspection of the average film taken on complete inspiration shows that the apices of the lungs are covered by the first and second ribs, and occasionally by the third. In some cases the clavicle completes the obstruction of the apex. Further inspection reveals that the periphery of the first anterior interspace or part of the apex is covered by the clavicle. This disadvantage of the film is emphasized in the long narrow chest, where the bones are large, and sometimes by the stooped position the patient has or assumes when the film is taken. Because of the overlying first and second ribs, apical pleuritis and subminimal apical lesions are frequently not visible on the film, and, as already stated, small lesions in the clavicular region may be entirely covered by bones. This explains why small infiltrates are rarely overlooked on roentgenoscopy though frequently missed on the film. As noted in the table, roentgenoscopy was found to be much more effective than the single film in finding small apical, and clavicular lesions. Likewise, thickening of the apical pleura was much more frequently discernible on roentgenoscopy than on the film, because of overlying first and second ribs which so frequently obscure the extreme apices.

Blood vessels simulating calcified tubercles are easily distinguishable by roentgenoscopic examination, and diaphragmatic adhesions are also more easily demonstrated. On the other hand, abnormalities in bones are more frequently determined on the film.

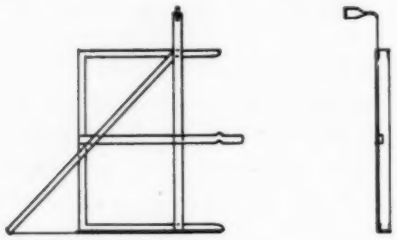
METHOD OF EXAMINATION

The examiner should accommodate his eyes to darkness by wearing goggles before entering the roentgenoscopic room, and at all times when entering a lighted room between examinations. He should arrange his schedule so that he can examine a specified group without often emerging from the roentgenoscopic room. The subject is examined with the clothing removed to the waist, facing the roentgenoscope, with shoulders rotated forward, thus keeping the scapulae out of the lung fields. The entire thorax is first surveyed, noting any asymmetry. The neck is examined for calcified cervical lymph nodes. Any abnormality of the bony framework is noted, such as the presence of cervical ribs, and structural defects of the ribs and spine. The movement of the ribs and diaphragm is then observed, search especially being made for localized limitation of motion, presence of adhesions and the obliteration of the costophrenic angles. The heart, aorta, mediastinum, and retrocardiac space are next examined in the posteroanterior, anteroposterior, right and left oblique, and lateral views, and abnormalities noted. The hilum is then studied and the extent of its outer boundary noted. It should not normally extend beyond the inner third of the pulmonic field. Examination of the hila is probably the most unsatisfactory part of the examination, for though the hilum may appear "muddy" in certain parts, the density noted may not be sharply enough defined or sufficient in detail to tell definitely that it represents a calcified deposit. Distinction

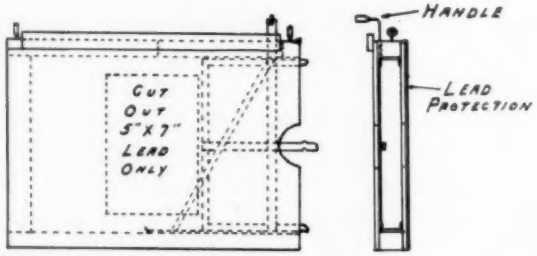
between blood vessels on end and calcifications slightly removed from the hilum is readily and easily made by rotating the patient.

Finally the lung fields are examimed. With the shutters of the roentgenoscope wide open a general survey of the lungs is made. Any large infiltration is readily seen. With the shutter arranged to expose a 3 inch strip of lung, homologous parts of the two lungs are compared. Lesions are most easily brought into view by constantly turning the patient from side to side as the screen is slowly elevated and all parts of the lung are brought successively into view. The apices, clavicular, and subclavicular regions are closely inspected in all positions with the scapulae drawn both up and down, but always forward. Closer inspection of these important portions of the lung field should be done with the shutter of the diaphragm so regulated that only small parts of the lung can be examined successively. The extreme apices can best be brought into view on deep expiration and by tilting the thorax either anteriorly or posteriorly.

The entire routine is repeated while the patient faces the examiner. Since most infiltrations are in the posterior part of the lung, they usually appear larger when the patient faces the examiner.



FRAME FOR HOLDING CASSETTE



FILM TUNNEL WITH CASSETTE HOLDER IN PLACE.

END VIEW.

FIG. 1

ROENTGENOSCOPIC "SPOT" ROENTGENOGRAMS

Convinced by the experience of continued use of the roentgenoscope of its advantages over the routine films,[9] a method to prove this contention was sought. To fortify and prove its advantage over the film, it was necessary that a permanent record of the image seen on the fluoroscopic screen be made available for comparison with the routine film.

This was made possible by constructing a cassette holder which can be attached to the fluoroscopic screen. The cassette device (Fig. 1) is primarily a long narrow tunnel, the framework of which is constructed of wood, and completely covered with a sheet of lead, except for a 5" × 7" aperture through which the patient is "positioned" for the spot film. A second smaller frame holding the cassette was constructed to fit and move freely in the larger lead covered wooden frame. By means of the handle extending from the upper edge of the frame (Fig. 1) the cassette is pushed into the 5" × 7" aperture after the lesion is in position just before the film is to be taken.

When not in use the cassette holder is suspended from the ceiling out of the examiner's way. It hangs, counterbalanced by two pulleys attached to sash weights, directly over the fluoroscopic screen. After the lesion is spotted, the cassette holder is pulled down and attached rigidly to the screen. This firm attachment is made possible by an inverted U-shaped metal channel running along the upper posterior edge of the screen. By this arrangement none of the motility of the screen is lost though the field of vision is limited to the 5" × 7" lead-

free aperture. This aperture gives the examiner a final chance to view and adjust the position of the lesion before the cassette is slid into place and the film taken. This privilege is comparable to the final look the professional photographer takes before he finally releases the shutter of his camera.

The roentgenoscope used is equipped with a Patterson "B" type screen and the tube has a focal spot of 1.5 mm. The importance of the screen, and especially the fine focal spot, should be stressed, for small lesions visible with a 1.5 mm. focal spot are sometimes not visible with a larger focal point. One big advantage of roentgenoscopic spot roentgenography is its low cost. The small films may be purchased for approximately one-eighth to one-sixth the price of the large 14″ × 17″ films. It is evident that several films of the lesions may be taken in different positions at a cost of less than the single large film. With the passage of time and development of equipment expecially designed for the type of chest study described, technical improvement should result in producing better spot films.

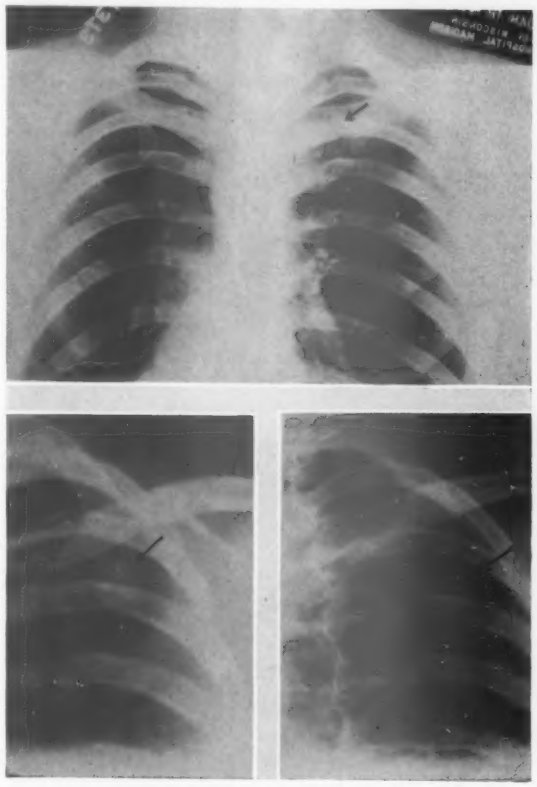


Fig. 2

A COMPARISON OF THE ROENTGENOSCOPIC SPOT ROENTGENOGRAMS AND THE ROUTINE POSTEROANTERIOR FILM

As already reported[9] certain lesions not visible on the routine roentgenogram are readily brought into view on the fluoroscopic screen. The extent to which this is possible can be shown by comparing the routine and the roentgenoscopic spot roentgenograms.

Figure 2 illustrates a lesion which demonstrates the fallacy of complete reliance on the routine posteroanterior film to determine whether or not an infiltrate is present. To each interpretation of lung films as usually reported should be added the reservation—" as far as can be seen." The film as interpreted by a competent roentgenologist was reported as follows: "There is a little trunk accentuation in the right vertebral area. Otherwise negative." The film showed no more than the report indicated. Note, however (Fig. 2), to what extent the lesion was visible by roentgenoscopy as indicated by the spot films taken in both anterior and posterior oblique views. Small lesions, in my experience, lying at the extreme lung apices the lung periphery, and under the clavicles and ribs are less likely to escape detection by roentgenoscopy than on the film.

Figures 3 and 4 represent two subminimal apical lesions with apical pleuritis not visible on either single or stereoscopic films. These cases illustrate how extremely small lesions are capable of being found by roentgenoscopic examination. Both escaped detection on routine films because of their positions at the lung apices. It has been found that in most instances lesions at the extreme lung apices can be seen to better advantage if the films are taken on complete expiration rather than on inspiration.

Figure 5 illustrates to what extent an apical lesion, though visible on both single and stereoscopic films, can be shown in

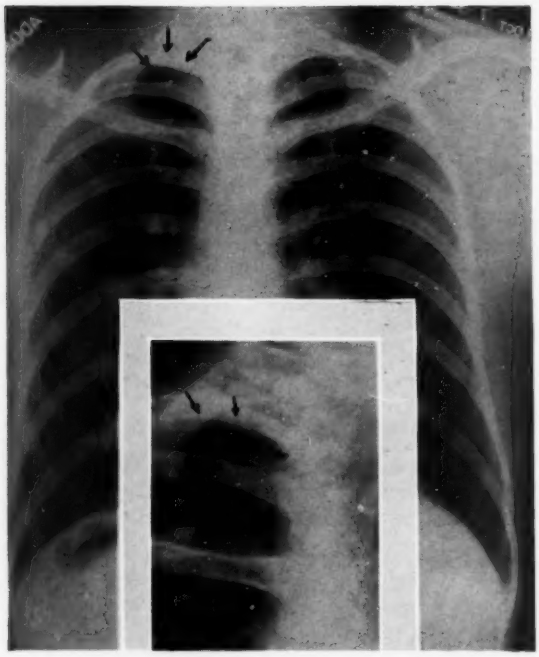


FIG. 3

greater detail and more exact position on the spot films.

Figures 6, 7, 8 and 9 show clavicular infiltrates which have escaped detection by the routine roentgenogram or show to much better advantage on the roentgenoscopic "spot" film. The case represented in Figure 6 is of special interest for, according to serial roentgen studies over a period of two years, the lesion was showing constant retrogression. Roentgenoscopy and spot films, however, showed that extension was occurring in another plane. Laboratory studies were consistent with an active and progressive lesion. Figure 7 illustrates a clavicular lesion entirely obscured by the left clavicle, but clearly brought into view on roentgenoscopy as shown by the spot film.

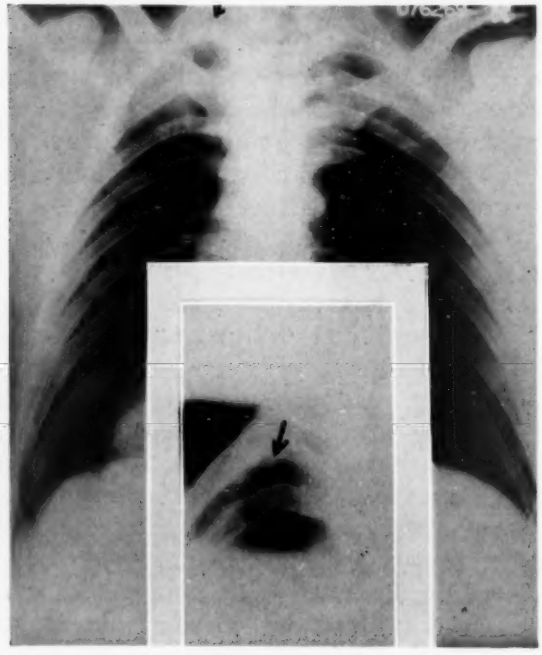


FIG. 4

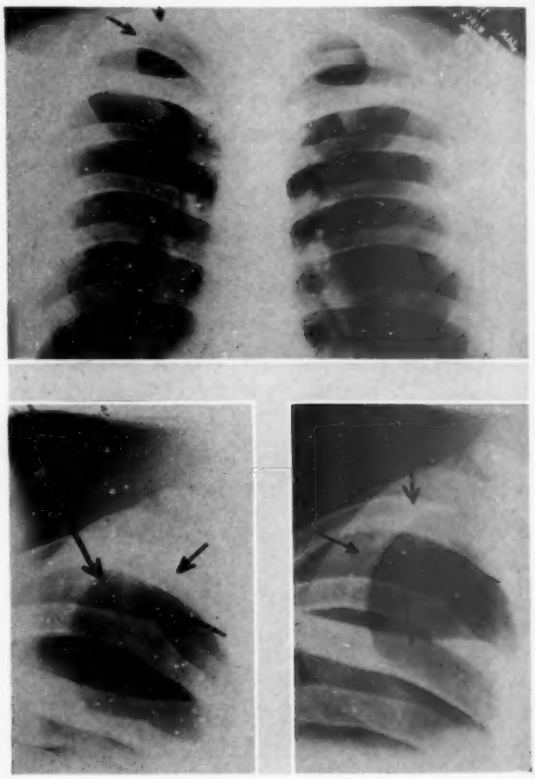


FIG. 5

In Figure 8 is seen a shadow in the left first interspace interpreted as "suspicious" in the film. However, there can be no doubt of the presence of the lesion in the smaller spot films taken in both the anterior and posterior oblique views. Figure 9 shows an-

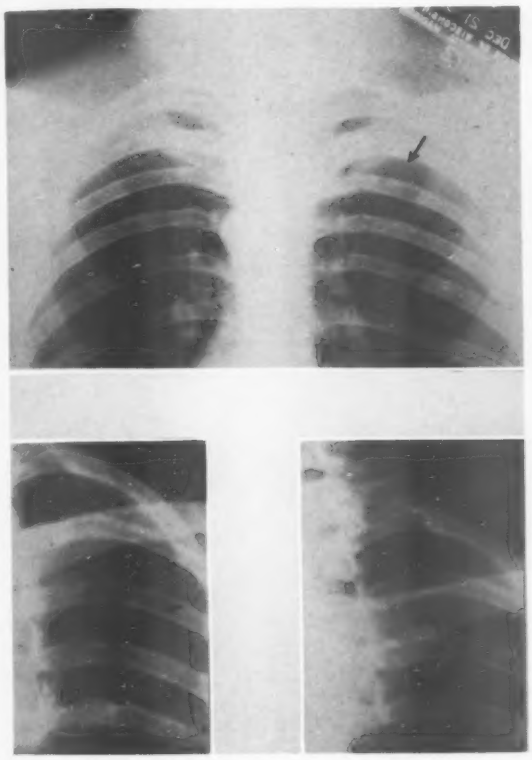


Fig. 6

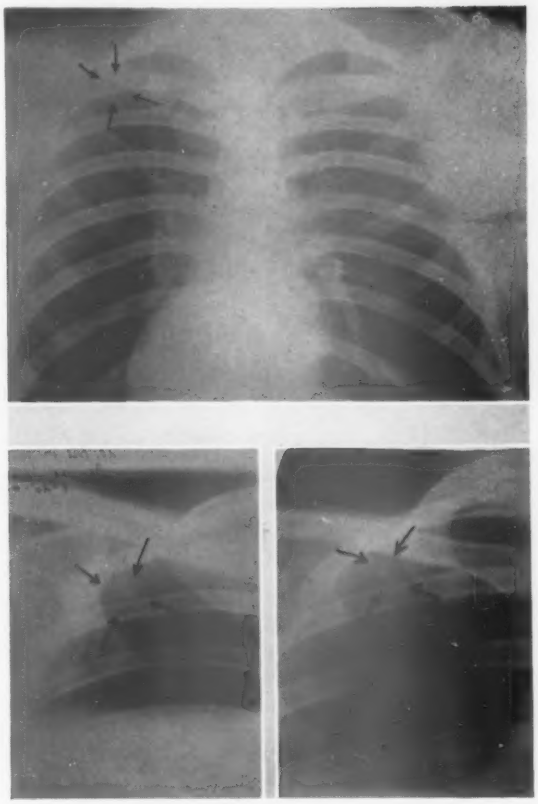


Fig. 8

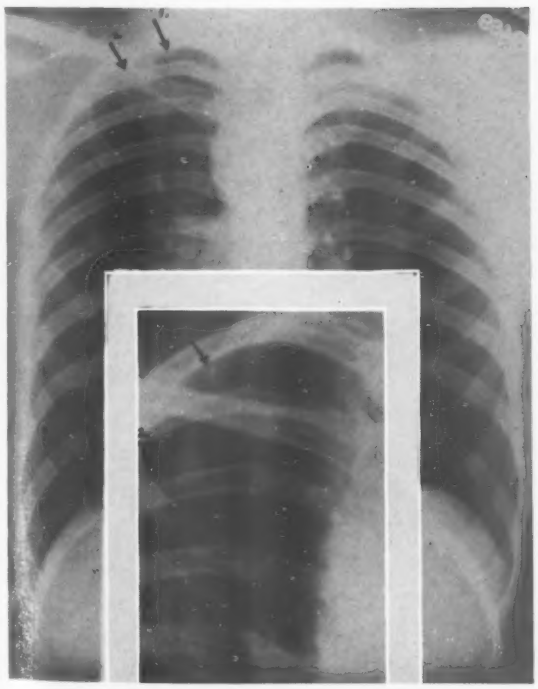


Fig. 7

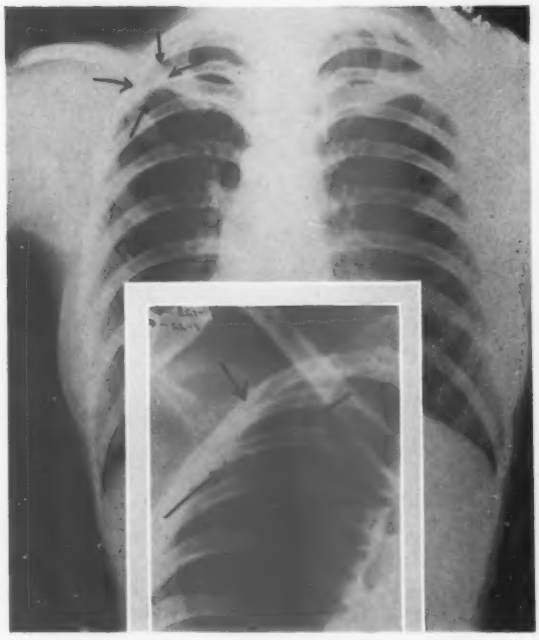


Fig. 9

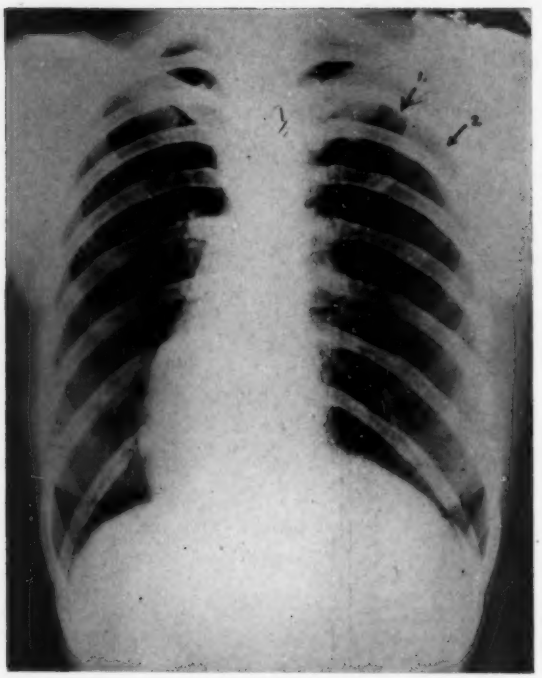


FIG. 10

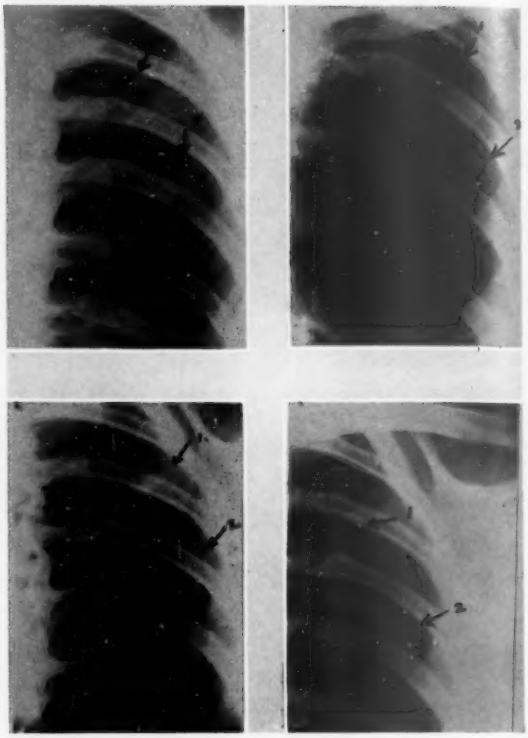


FIG. 11

other clavicular lesion largely hidden by the clavicle.

Figure 10 shows a routine film with lesions in both the right first and second interspaces. The lesion in the second interspace is well out in the periphery. Note to

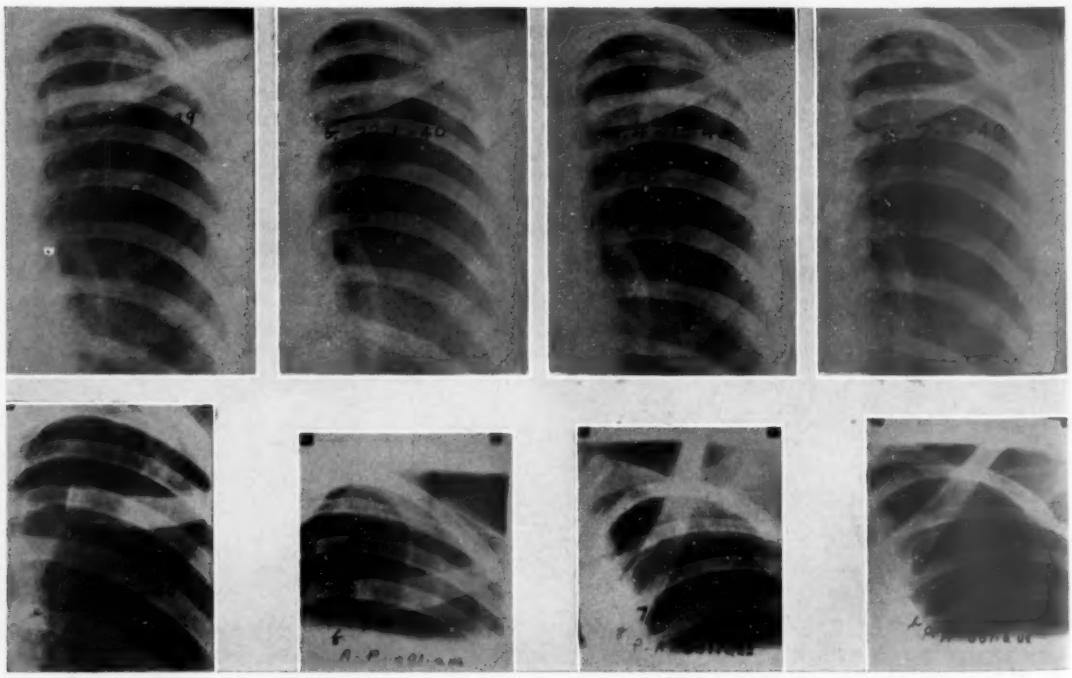


FIG. 12

what extent the four spot films (Fig. 11) give additional information relative to the size, shape, extent, and character of the lesion.

DETERMINATION OF CAVITATION

Cavities, especially those thin walled, well out in the periphery, and located in the apical and clavicular regions, where they are often obscured by the bones in the routine films can be brought into view on the screen of the roentgenoscope. With the aid of the spot film device, a roentgenogram can be taken which shows the cavity to the best advantage, and on the spot film there is no question of its identity.

In Figure 12 on the dates indicated and marked *a*, *b*, *c*, and *d*, are roentgenograms taken on 14″ × 17″ films, but to conserve space show only part of the right lung. Though the presence of a cavity might be suspected in these films, there was no question of its presence in certain positions on the fluoroscopic screen. The cavity as it was seen in the anteroposterior oblique view by roentgenoscopy is shown in the spot films marked *e* and *f*. In the posteroanterior oblique views (spot films marked *g* and *h*) the cavity does not show to the same advantage as in the anteroposterior oblique, and represents the same difficulty of definition encountered in the routine film. This particular case illustrates an advantage of roentgenoscopy. By roentgenoscopy it is possible to place the walls of the cavity in the position in which they cast their densest shadow. Because it is probable that most cavities are not spherical the shadow cast by cavity walls is dependent on position. The advantage of position is usually obtainable on roentgenoscopy.

Another instance of the difficulty of determining the presence of a cavity is illustrated in Figure 13. Stereoscopic films marked *A* and *B* and interpreted by a competent roentgenologist failed to show sufficient evidence to warrant an interpretation of the presence of a cavity. On roentgenoscopy the cavity as it was noted both before and after the stereoscopic films were

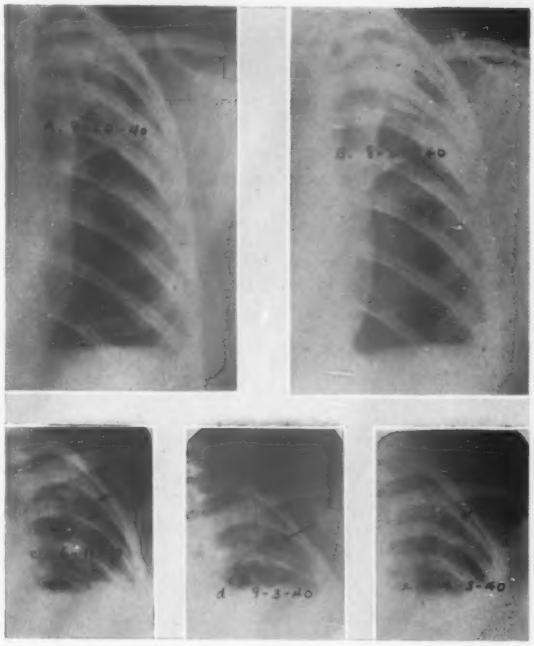


Fig. 13

taken is shown in the spot films marked *c*, *d* and *e*.

CONCLUSIONS

1. A method for the diagnosis and detailed study of pulmonary lesions by means of roentgenoscopy with an attachment for spot roentgenography is described.

2. The skepticism existing at present regarding the limitations of the roentgenoscopy in making visible small parenchymal lesions is unwarranted. The opinion is held that in trained hands roentgenoscopy is more efficient in finding minimal lesions, especially of the parenchyma, than are single or stereoscopic films. The advantages of the described method are self-evident.

3. The prediction is made that in the future adequate study of the lungs will not be considered concluded without a roentgenoscopic examination.

4. "Spot" roentgenograms have a distinct advantage over routine films because they may be taken from the position or positions to show the extent, location, and type of lesion to best advantage.

I wish to express my appreciation to Mr. L. J. Dorschel for his assistance in constructing the cassette device.

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A METHOD FOR THE LOCATION AND MEASUREMENT OF INTRAPULMONARY CAVITIES AND FOREIGN BODIES

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THE work represented by this paper was stimulated by the repeated requests of the various attending physicians and surgeons at routine Staff Meetings at the Otisville Sanatorium for more complete data concerning the location of pulmonary cavities than was available by the routine 6 foot projection and tomographic studies ordinarily made. It has been further stimulated by the recent increase in the interest concerning and the use made of the Monaldi method of intercavitary drainage. It was thought that if intercavitary drainage is to play an increasingly important part in the treatment of giant cavities of the lung in Otisville, there should coexist with this relatively new technique a more complete and accurate study of the location and size of pulmonary cavities. Preliminary study of this subject has led to several conclusions:

The first of these is the conviction that the frontal projection, lateral projection, oblique projection, planigraphy, inspiration-expiration studies and lordotic apical projections now used routinely, still fail in a considerable percentage of cases to locate a cavity with sufficient accuracy to permit plunging a trocar and cannula into the depth of that cavity with certainty. This difficulty obtains primarily in cases in which visualization has been made difficult by the introduction of air into the pleural cavity with resulting encapsulated air pockets.

The second observation is that magnified distortion is the chief guide in roentgenoscopic examination of a cavity case as to the exact location of that cavity and that we seem to make very little use of this fact in our roentgenographic studies of cavities. It will be at once apparent that when a patient with cavity is roentgenoscoped in the posteroanterior position, e.g., with the patient facing the fluoroscopic screen, if that cavity is in the anterior plane of the chest it will appear relatively small owing to its nearness to the screen, and when this same patient is turned slowly into the anteroposterior position, e.g., with the patient's back to the screen, this cavity gradually increases in size under the examiner's eyes, owing to the fact that it gradually gets farther away from the screen, thereby increasing its magnified distortion with the short focus ordinarily used in roentgenoscopy. When the size of the cavity undergoes no significant change as the patient is rotated from the posteroanterior to the anteroposterior position under the roentgenoscope this is the guide to the fact that that cavity must be approximately in the center of the anteroposterior diameter of the chest. In other words, with the same patient and the same cavity two different size images are produced on the fluoroscopic screen depending upon the variable factor of magnified distortion, and the difference in size between these two images is directly proportional to the distance of the cavity from the center of the chest or from the skin surface.

The work which follows makes use of this variable factor of magnified distortion in accurately measuring the location of a cavity within the lung. Our objective has been to discover a method for localizing the intrapulmonary cavity which is mathematically correct and yet is sufficiently simple to be practicable for every day use. Further study of the method to be presented led to the conclusion that it may also be applied to foreign bodies. The method is simple but entails the application of a formula. It consists of taking an anteroposterior and a posteroanterior projection of a cavity, with standard Potter-Bucky technique, measuring the shadows of the cavity and applying these values to a

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simple formula. The solution of the formula gives the depth of the cavity below skin level.

Our procedures were as follows: For the purpose of reducing the factors to a mathematical equation we created a hypothetical situation, which is illustrated in Figure 1. Figure 1 is a diagram in which the vertical

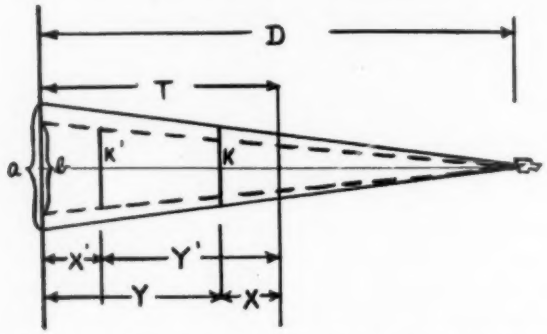


FIG. 1. K, diameter of cavity; T, thickness of chest on which roentgen technique is based; D, 30" focal distance; a and b, image of K in the two positions; X, distance from cavity to nearest chest wall; Y, distance from cavity to farthest chest wall plus table factor.

line on the left represents a roentgen film. Line D represents the focal distance between this film and the roentgen tube. Diameter T represents the thickness of the patient's body and, where Potter-Bucky technique is used, the distance from the top of the Potter-Bucky table to the film underneath the table is also included in this distance T. This latter distance, that is to say the distance from the top of the Potter-Bucky table to the film is hereinafter referred to in this article as the table factor. The Potter-Bucky table used in this work had a table factor of 4 cm. The vertical diameter K, of which there are two, represents the location of any cavity in both the anteroposterior and the posteroanterior position, while X and Y represent the distance of the film to the cavity in these two positions and a and b represent the shadows cast by the cavity while in these two positions. Shadow a being cast by the cavity when it is located farthest from the film, of course has more magnified distortion and is therefore larger, and shadow b being cast by the cavity when it is nearest the plate is smaller. It is possible, therefore, mathematically, to construct the following equation:

$$\frac{K}{a}=\frac{D-Y}{D} \quad \text{or} \quad \frac{K=Da-aY}{D}$$

$$\frac{K}{b}=\frac{D-X}{D} \quad \text{or} \quad \frac{K=Db-bX}{D}$$

$$\therefore \quad Da-aY=Db-bX \quad \text{or} \quad bX-aY=Db-Da$$

but $$X+Y=T$$

and $$aX+aY=aT$$

$$aX+bX=aT+Db-Da$$

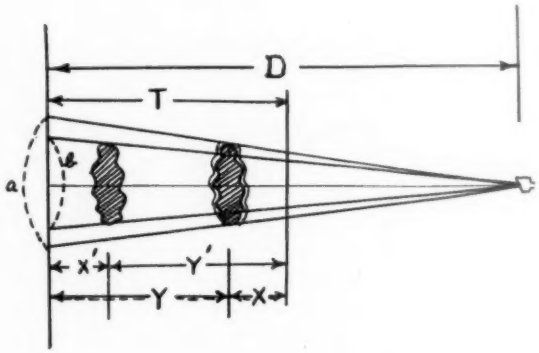
$$X=\frac{Ta+Db-Da}{a+b}$$

or $$X=\frac{Ta+D(b-a)}{a+b}.$$

Solving likewise for Y

$$Y=\frac{Tb+D(a-b)}{a+b}.$$

By using the formulae developed from Figure 1 we have a situation in Figure 2



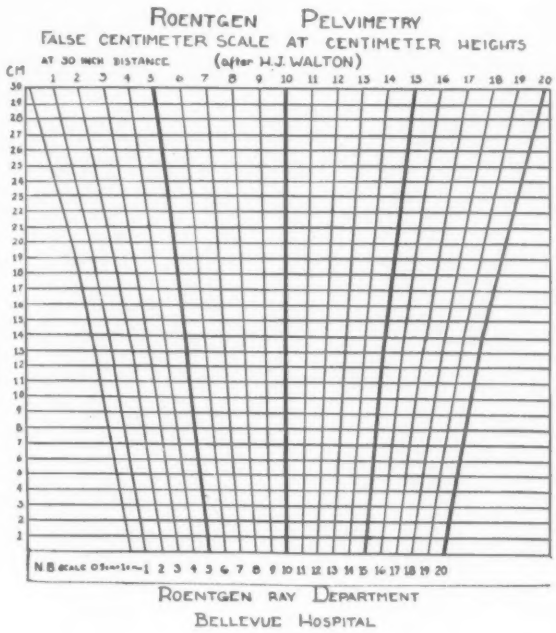
$$X = \frac{D(b-a)+Ta}{a+b}$$

$$Y = \frac{D(a-b)+Tb}{a+b}$$

FIG. 2. X in the equation represents the distance from the cavity farthest from the film to the nearest skin distance.

which would be applicable to any case of pulmonary cavity in which D and T are known factors in the technique of the roentgen exposures and a and b are found by measuring the shadows of the cavity on the anteroposterior and posteroanterior films, and therefore by simple substitution in this

CHART I


ROENTGEN PELVIMETRY
FALSE CENTIMETER SCALE AT CENTIMETER HEIGHTS
AT 30 INCH DISTANCE (after H.J. WALTON)
CM
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
ROENTGEN RAY DEPARTMENT
BELLEVUE HOSPITAL

formula we can calculate the value of X and Y and, as in Figure 1, they represent the distance from the film to the cavity in both the anteroposterior and posteroanterior positions and their sum is therefore equal to the thickness of the chest plus the table factor. This formula is based essentially on the method of triangulation described by Friedman, Michels and Rossitto[4] in 1935. We are therefore able to determine the distance of the greatest diameter of the cavity in any chest from both the anterior and the posterior planes of the chest by the simple procedures of taking an anteroposterior and a posteroanterior projection of that cavity with the usual 30″ Potter-Bucky technique, measuring the shadows of the cavity and substituting these values in a simple formula.

The greatest diameter of this cavity can easily be determined mathematically by reverting again to Figure 1, because we are now able to supply values for the factors X and Y, which in the beginning were unknown. We could therefore solve the equation for the remaining common factor K which represents the diameter of the cavity. However, this mathematical calculation might be somewhat cumbersome for everyday use and therefore I have reverted to the principle embodied in the Walton magnified distortion chart for pelvic mensuration. In order to adapt the Walton chart to the conditions of this technique, exposures were made of the Thoms perforated screen using a 30″ Potter-Bucky distance and exposing films with this perforated screen at intervals of 5, 10, 15, and 20 cm. respectively, from the films. The magnified distortion shown in these roentgenograms was transferred to the Walton chart (Chart 1). It will be noted from this chart that the greater the distance from the base line, the wider the spread of magnified distortion of the original centimeter distances marked on the base line. It now becomes possible by the simple application of a ruler to this chart to instantly determine the actual size of the cavity. If, for example, any cavity has been found to lie at a depth of 10 cm. and the image of that cavity at this depth measures 4 cm., then the ruler is laid on the 10 cm. line and 4 cm. are marked off. This mark is projected down to the base line in the same relative position to the fan-shaped lines and the actual size of the cavity is read from the base line. This value will, of course, be smaller than the measurement of the cavity on the roentgenogram. This reading will apply to the greatest diameter of the cavity and does not take into account any of its irregularities. We have, therefore, by two simple steps located the depth of a cavity in the body and the size of its greatest diameter. This same technique may be applied to the lateral positions of the body, in which case the depth of the cavity from the lateral chest wall is determined in exactly the same manner.

In general, it is possible with this meth-

od to calculate the depth of a cavity from any given point on the surface of the chest by making two exposures of that cavity in opposite directions and determining the thickness of the patient's chest in the plane of these exposures. It must be kept in mind that the value derived by the solution of the equation represents the distance from the greatest diameter of the cavity to the surface of the body and totally ignores any irregularity in shape, e.g., a diverticulum-like projection from the side of the cavity or a multilocular character of the cavity would be recognized by this equation only so far as it affects the total transverse diameter of that cavity. It is apparent, also, that the images of the cavity, small and large, on the two roentgenograms must be measured in the same plane, i.e., either both vertically or both transversely. This method would seem to have its greatest value in determining the depth of the cavity in that type of chest in which there are technical difficulties in visualizing the cavity in the ordinary lateral and oblique projection. It is conceivable that this method of localization will have a practical application for objects other than pulmonary cavities, such as foreign bodies sufficient in size to make a measurable image on the roentgenogram.

CHART II

Measurement								Distance in cm. cavity or foreign body to				Walton Diameter	Case
Chest													
Antero-posterior	Lateral	D	T	a	b	Formula	Solution	Front	Back	R	L		
17.7		75.7	21.7	P.A. 4.4	A.P. 4.1	$X=\frac{75.7(4.1-4.4)+21.7\times4.4}{4.1+4.4}$	8.56		8.56			3.8	I G.M.
						$Y=\frac{75.7(4.4-4.1)+21.7\times4.1}{4.1+4.4}$	13.13	9.13					
Body	Arm												
16.0	6.0		26.0	A.P. 6.7	P.A. 5.4	$X=\frac{75.7(-1.3)+26\times6.7}{6.7+5.4}$	6.25	6.25					II A.L.
Foreign body 4.9						$Y=\frac{75.7(1.3)+26\times5.4}{6.7+5.4}$	19.73		15.73			4.85	
	29.1		33.1	R.L. 4.1	L.L. 3.0	$X=\frac{75.7(-1.1)+33.1\times4.1}{7.1}$	7.38				7.38	2.7	I G.M. Lateral
						$Y=\frac{75.7(1.1)+33.1\times3.0}{7.1}$	25.71			21.71			

Chart II illustrates the use of this method in three different types of cases. These were chosen out of many test cases to illustrate different applications of the method described. The first is an anteroposterior and posteroanterior projection through a pulmonary cavity. The second instance illustrates the use of this method through lateral projections of a pulmonary cavity and the third case illustrates its use for the localization of a foreign body. It will be ob-

served in Case 1, G. N., that the actual measurements of the chest in anteroposterior and lateral projection are indicated as 17.7 and 29.1 cm. respectively. *D* represents the focal distance used, which is always 30 in., or 75.7 cm. *T* represents the anteroposterior diameter of the chest plus the table factor of 4 cm. because Potter-Bucky technique was used throughout in this work. *A* and *B* respectively indicate the measurement of the shadow of the cavity as projected on the posteroanterior and anteroposterior films. This is illustrated in Figure 3. These values have been substituted in the formula for *X* and *Y* and their solution is indicated under the columns marked "Solution for *X* and *Y*." The distance of this cavity to the back of the body is obviously the value which has been derived for *X* and the distance of the cavity to the front of the body is the value which was derived for *Y* minus the table factor. By application of the values for *A* and *B* to the levels indicated by *X* and *Y* on the Walton chart, we determine that the diameter of this cavity is 3.8 cm. At the bottom of this chart, labeled Case 1, lateral, the same procedure is followed except that the projections are made laterally to the chest and the distances determined from the cavity to the right and left chest walls. In Figure 4 the diameter of the cavity seen from this angle is 2.7 cm. Case 11, A. L., represents the application of this formula to the determination of the depth of a foreign body. In this case a foreign body was fastened to the anterior chest wall and the patient's arm firmly strapped to the chest wall over the foreign body. The thickness of the body and the arm, under these conditions, was carefully measured as a control and found to be respectively 16 and 6 cm. (see Fig. 5). The value of *T*, therefore, becomes 26, e.g. 16 plus 6 plus 4. The actual measurement of the foreign body itself, for control purposes, is 4.9 cm. Measuring the two

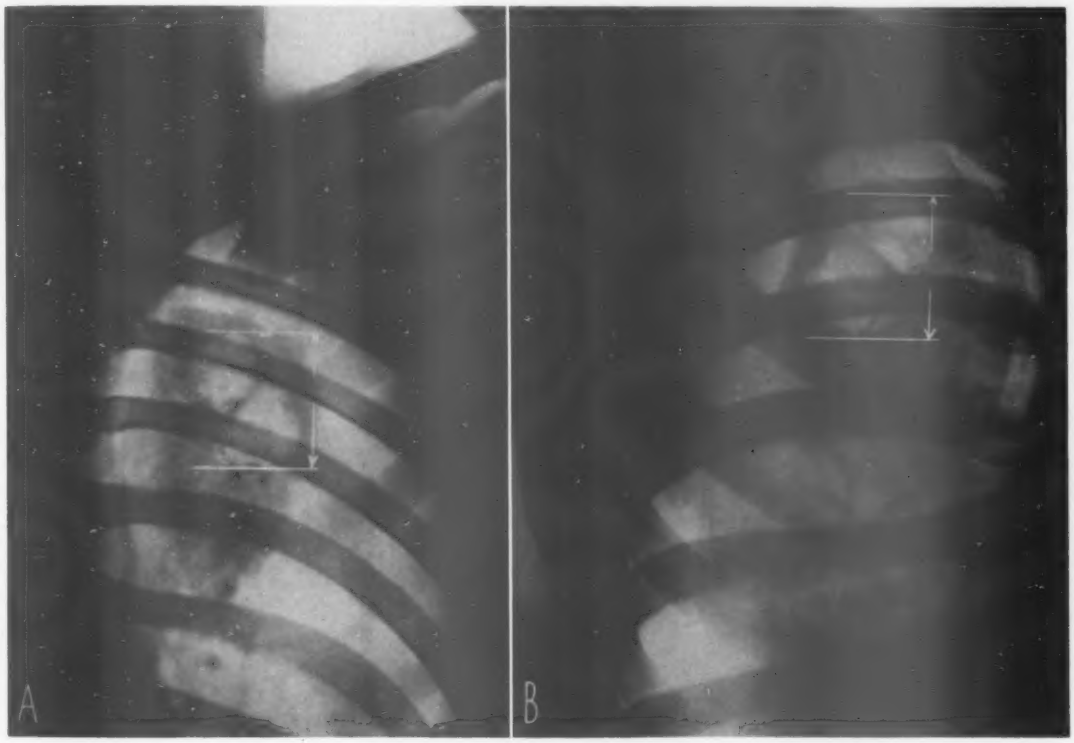


Fig. 3. *A*, anteroposterior projection; *B*, posteroanterior projection.

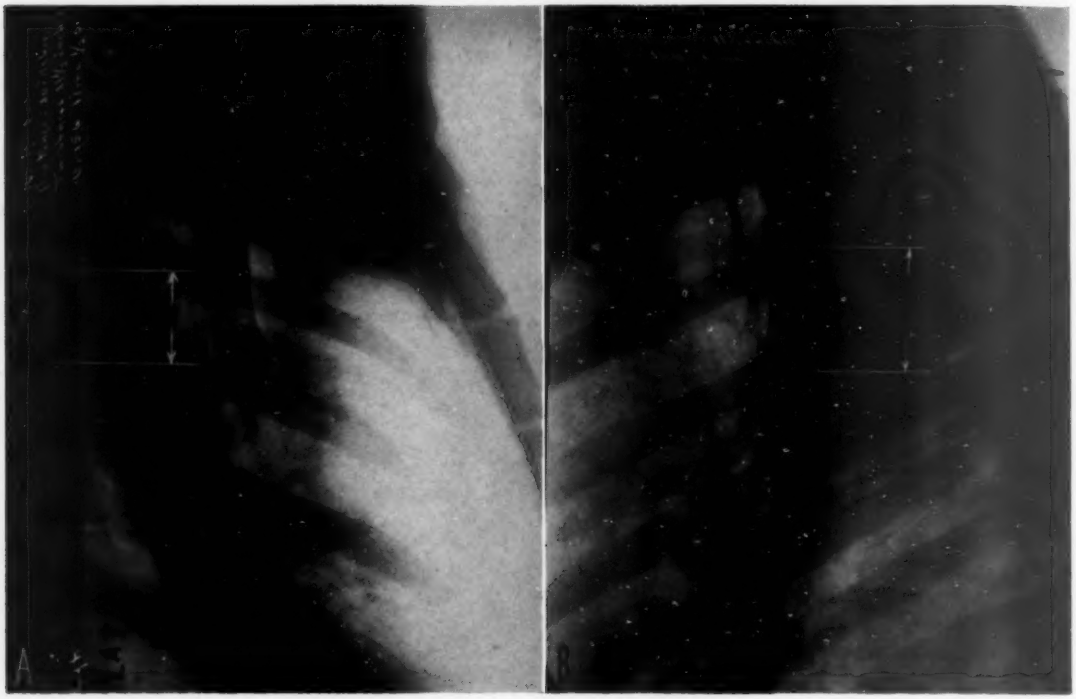


FIG. 4. *A*, left lateral projection; *B*, right lateral projection.

shadows of the foreign body gives a value of 6.7 plus 5.4 cm. for a plus *b*. Substituting in the formula for *X* and *Y* we arrive at the conclusion that the distance of the foreign body is 6.25 cm. from the front of the body and 15.73 cm. from the posterior plane of the body. We already know that the actual measured distance is 6 cm. and 16 cm. By the application of the Walton chart we determine that the length of the foreign body is 4.85 cm. We have already measured it and found it to be 4.9 cm. We therefore conclude that the calculations are within the usual limits of accuracy found in mensura-

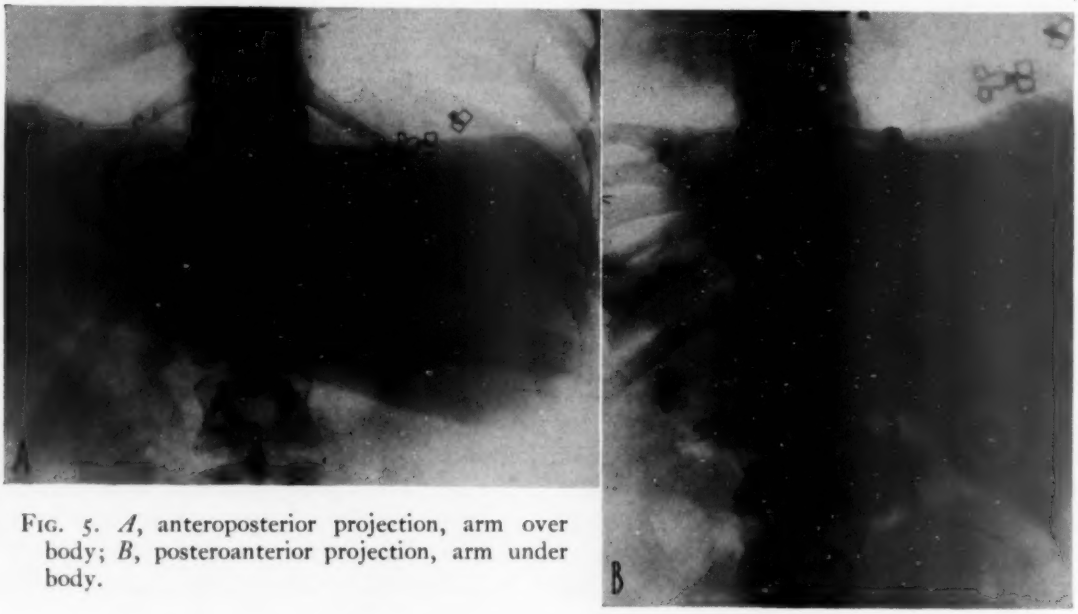


FIG. 5. *A*, anteroposterior projection, arm over body; *B*, posteroanterior projection, arm under body.

tion based upon magnified distortion.

This method has been applied to many cases in each of these three categories and approximately this same percentage of accuracy has been obtained throughout. In at least one case, in the large series of pulmonary cavities studied by this method, the cavity was definitely shown to be in the posterior pancake collapse of a pneumothorax and in this case location of the cavity was extremely difficult or impossible from the ordinary tomographic lateral and oblique projections owing to a very unusual pocketing of gas in and about the collapsed lung.

Certain inherent errors exist in this and all similar procedures. The first of these is the possibility of error in measuring the chest or other parts of the body. This will be in proportion to the care exercised in measuring the part and in the case of the chest any difference existing in the inspirational phase between that of measurement of the chest and the actual taking of the plates will introduce an error. The second error, which is largely theoretical, may be realized by referring to Figure 2. It will be evident that the rays which delineate the greatest diameter of the cavity or foreign body are tangential to that cavity or foreign body at a different point on the circumference of the cavity or foreign body in making image *A* than in making image *B*. This error is extremely slight and is represented by the difference between the measured *T* and the computed values of *X* and *Y* in Chart 1, all other factors being equal. This has no practical significance. A third possible source of error lies in the measurement of the images of the cavity on the roentgenograms. It will be noted that the differences in value between the measured image *a* and *b* is a small fraction of a centimeter and this slight difference is projected mathematically into a final value of several centimeters. This differential between *a* and *b* can be increased to a larger and more easily manageable difference by using a shorter focal distance than 75.7 cm., and the shorter the focal distance, the more accurate the measurement of the difference between *a* and *b* becomes. This focal distance can be shortened indefinitely within the limits of practical roentgen technique for the demonstration of the cavity. The present studies have all been carried out at 75.7 cm. focal distance because this is the most commonly used focal distance with all Potter-Bucky tables, and it was primarily desired to determine the feasibility of this method with the ordinary everyday equipment existing in every hospital roentgen department without radical change from routine procedures.

CONCLUSIONS

(1) A simple method has been presented for the quick measurement of the depth of a cavity or foreign body below the skin level.

(2) The mathematical background for the method has been presented and the formula given.

(3) The limitations of the method have been described.

I wish to express my gratitude to Elwood Wilbur for his assistance with the mathematical equations.

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EFFECTS OF ROENTGEN IRRADIATION AT LOW TEMPERATURE ON THE SKIN OF YOUNG RATS*†

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ONE OF THE difficulties in studying effects of low temperature on radiation injury of mammalian tissue has been that of maintaining a constant low temperature. I became interested in a technique employed by some of my associates in endocrinology which was to prepare young rats for operation by chilling them with ice.‡ These baby rats (one to three days after birth) can be chilled very rapidly and completely at 0° C. and, if the exposure is not too long, they will recover without any apparent ill-effects. It was considered advisable to determine whether such young rats at 0° C. are more resistant to roentgen radiation than those irradiated at room temperature.

MATERIALS AND METHODS

The animals (only males were used) were chilled before the irradiation by placing them in a refrigerator at 0° C. for about ten minutes. Snow was packed around them to keep the temperature low during the treatment.

The radiation was produced by a Coolidge tube with mechanical rectification operated at 130 kv. and 5 ma. The radiation was unfiltered (with the exception of 1 mm. of cardboard). The target distance was 27 cm. and the intensity was 135 r per minute (corrected to 0° C. and 760 mm. pressure). Unless otherwise specified the dosage employed was 1,350 r.

IRRADIATION OF SAME ANIMAL AT DIFFERENT TEMPERATURES

In Experiment 1 a day old rat was placed at 0° C. for ten minutes, then fastened to a sheet of lead with adhesive tape, and irradiated while packed in snow. The snow was held in place at the sides and back by a celluloid soap-box cover. The animal was irradiated through a slit cut out of the lead. This was cut in the shape of the letter "C." Such a procedure of irradiating through a stencil served to yield a visible skin reaction (loss of hair), the degree of which could be estimated by the distinctness of the letter produced. It also served to give a localized histological injury. After the irradiation at 0° C. the animal was allowed to regain its activity by placing it at 30° C. for ten minutes. It was then irradiated through an "H" cut in the lead at room temperature. Moist cotton was substituted for the snow of the previous experiment. The second region irradiated was well below that of the first treatment.

The irradiated regions were clearly marked by their respective letters "C" and "H" when examined six days later. The "H" was much more distinct than the "C" and only the skin of "H" was scaly in appearance. When examined ten days after the irradiation the animal had just been killed by the mother but the body was still intact. The "H" at this time showed extensive sloughing and was quite deeply impressed in the skin. The "C" was much lighter and was even less distinct at this time than when examined previously. The greater injury of the "H" area was even more evident in the microscopic preparations. The skin of each irradiated region (along with some adjacent untreated skin) was fixed in Bouin's fixative, sectioned at 10 microns, and stained (some with Delafield's hematoxylin and eosin, some with iron hematoxylin and some with Mallory's triple connective tissue stain).§ The greater resistance of the skin irradiated while cold is quite evident as shown in Figure 1. In this figure, *a* is of a section of skin from the region irradiated at 0° C. and little or no injury can

‡ It is a pleasure to acknowledge the cooperation of Professor Emil Witschi who supplied the animals from his rat colony, and I am also indebted to Dr. Witschi's research assistants for their help in caring for the animals.

§ The writer was ably assisted in this phase of the investigation by Dr. W. A. Robbie.

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† I wish to express my gratitude to Dr. H. D. Kerr who suggested this type of investigation and to Professor J. H. Bodine who has also helped in many ways to make this report possible.

be seen. The skin irradiated at 26° C., however, shows extreme injury (Fig. 1*b*). There has been excessive desquamation and the skin is quite thin. The epidermis is thickened and some of the cells show signs of injury. The hair is entirely missing in the irradiated region (central portion) and fibrous tissue is abundant.

Experiment II was a duplication of Experiment I with the exception that in this case the rat was two days of age when irradiated. The gross results were similar to those of the first experiment. No microscopic preparations were made of this animal as it was killed and eaten by the mother soon after an examination was made on the seventh day following the treatment.

Experiment III had to be discarded as the animal died before any results could be obtained. Experiment IV was designed to determine whether the sequence of the "H" and the "C" exposure would affect the results. Rat 1 of this experiment was irradiated first through the "H" at 27° C. and then later through the "C" at 0° C. Rat 2 was irradiated cold first and at room temperature later. In both cases the "H" was much deeper than the "C." The animals were irradiated on the left side through the "H" and on the right side through the "C." It was interesting to note that on the right side, at the time of the examination, the "H" produced by the radiation which penetrated through from the other side was stronger than the "C" resulting from the full dosage.

The results of this first series of experiments indicate that a region of skin irradiated at 0° C.

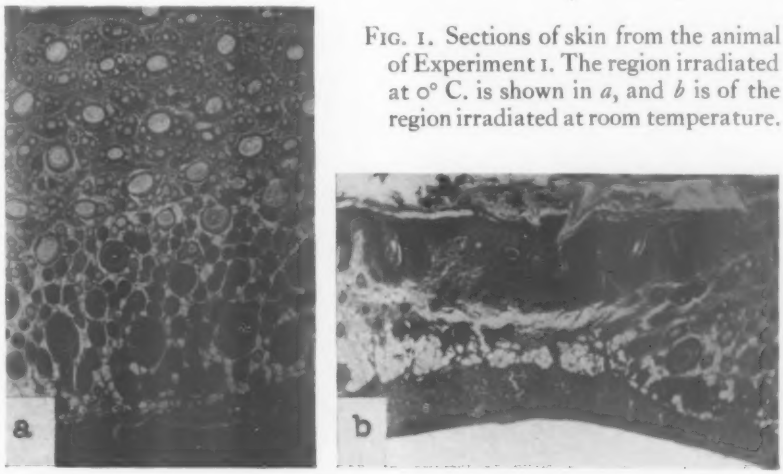

FIG. 1. Sections of skin from the animal of Experiment 1. The region irradiated at 0° C. is shown in *a*, and *b* is of the region irradiated at room temperature.

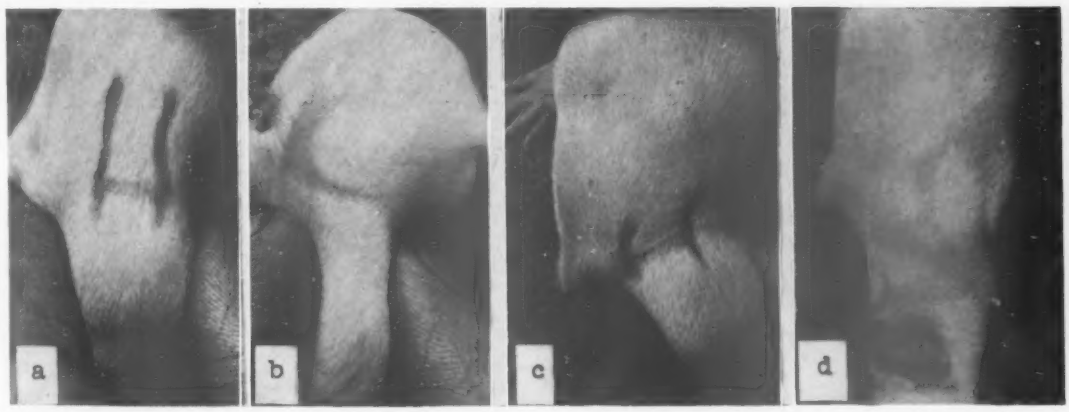

FIG. 2. Photographs of rats one week after irradiation. Note that the "H" markings of the animals irradiated at room temperature (*a* and *c*) are stronger than the "C" of those irradiated at 0° C. (*b* and *d*).

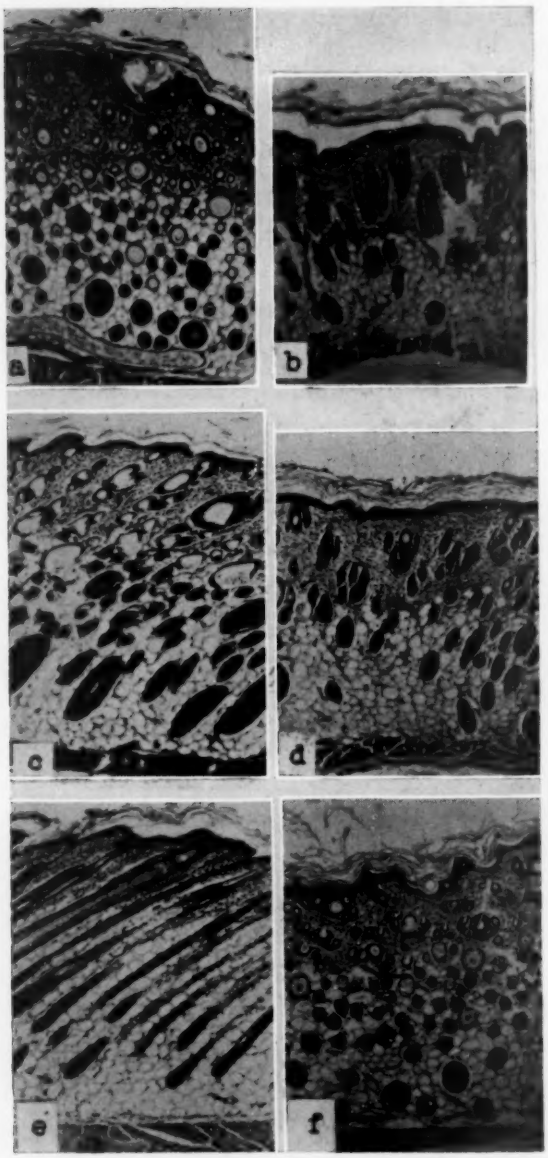

FIG. 3. Rat *a* was irradiated with a dosage of 1,380 r at 0° C., and rat *b* was exposed to only 920 r at room temperature. Animal *c* was irradiated with 920 r at 0° C. and *d* was treated with the same dosage at room temperature. Rat *e* was exposed to 1,160 r at 0° C., and *f* was irradiated with same dosage at room temperature.

is injured less than another region of the same animal irradiated at room temperature.

IRRADIATION OF LITTER-MATES, UNDER DIFFERENT TEMPERATURE CONDITIONS, AT THE SAME TIME

In these experiments one animal was taped below the "H" and irradiated at room temperature. Another rat was chilled, packed in snow and irradiated at the same time under the "C." In some experiments another rat was irradiated later at 0° C. to check possible variations due to individual susceptibility or irradiation technique. In all of these experiments the radiation injury of the rats irradiated at 0° C. was much less marked than that of those irradiated at room temperature.

In Experiment v the rats were three days of age when irradiated and were examined seven days later. The "H" at this time was much more distinct than the "C" as shown in *a* and *b* of Figure 2. The same procedure as above was followed in Experiment vi and similar results were obtained (*c* and *d* of Fig. 2).

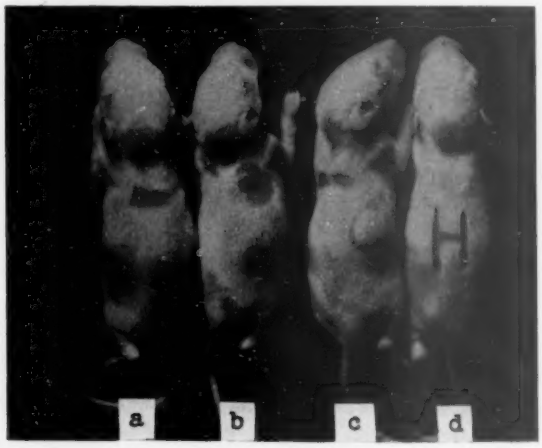

FIG. 4. Experiment IX. The two photographs are of the same rats taken under different conditions of lighting arrangements. Note that the injured areas of rats *b* and *d* (irradiated at room temperature) are much more prominent than those of rats *a* and *c* which were treated at 0° C.

In Experiment VII rats were irradiated on the third day after birth with a dosage of 1,840 r. This heavier dosage produced a more marked injury to the animal irradiated at room temperature but the injured region of the animal irradiated at 0° C. was still very indistinct.

Experiment VIII was planned to estimate the amount of radiation represented by the greater resistance of the skin irradiated at 0° C. A three day old animal was irradiated with a dosage of 920 r at 27° C., another was given 920 r at 0° C. and a third rat was exposed to 1,380 r at 0° C. At the time of the examination the "C" produced by 1,380 r appeared to be about the same as the "H" in distinctness, but microscopic examination indicated that its injury was much less marked (*a* and *b* of Fig. 3). Therefore, it appears that this difference due to the low temperature treatment must be equivalent to more than 460 roentgens.

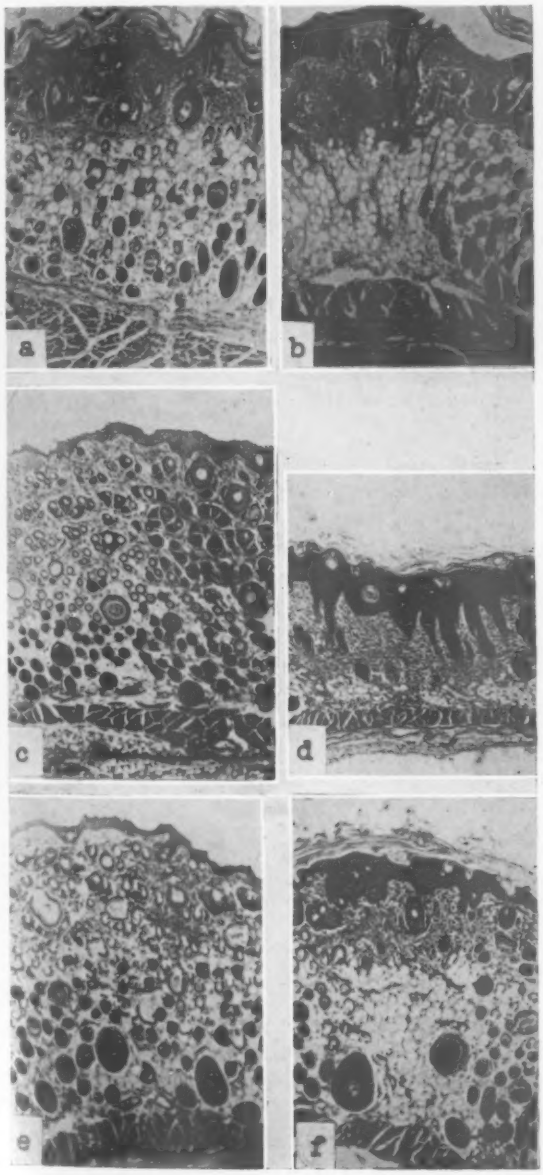

FIG. 5. The rats of *a*, *c*, and *e* were irradiated at 0° C. Those of *b*, *d* and *f* were treated at room temperature.

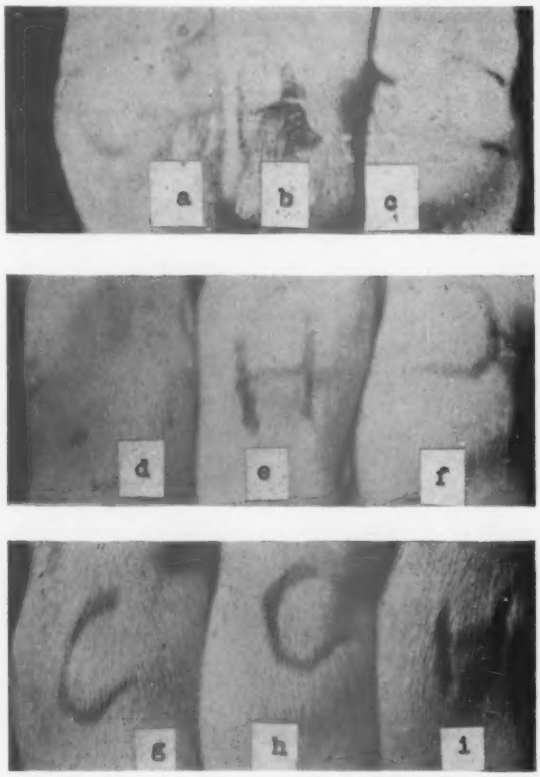

FIG. 6. Rats *a* and *c* were irradiated at 0° C. Note the marked injury of *b* which was irradiated at room temperature. The opposite side of the same animals are shown in *d*, *e* and *f*. The animals of *g* and *h* were irradiated at 0° C. whereas that of *i* was treated at room temperature.

In Experiment IX two rats were irradiated through the stencils and two others were treated through a portal 8×9 mm. The gross results are shown in Figure 4. These two photographs are of the same animals under different arrangements of light. Rat *a* was irradiated through the portal at 0° C. and it can be seen that the injury is much less prominent than that of rat *b* which was treated with the same amount of radiation at room temperature. Likewise, the injury of the "C" region (rat *c*) is less

marked than that of the "H" (rat *d*). Figure 3*c* is of a section of skin from the "C" region of the rat irradiated at 0° C. There is no definite sign of injury except for a slight thickening of the epidermis. The injury produced by the same amount of irradiation on the animal at 28° C. is shown in Figure 3*d*. This section shows thickening of the epidermis, a definite loss of hair follicles and some fibrosis. Figure 3*e* is a section of skin from the animal irradiated through the portal at 0° C. The skin appears to be unaffected except for possible thickening of the epidermis. The injury produced by the same amount of radiation at 28° C. is shown in Figure 3*f*.

In Experiment x, rats were irradiated five days after birth and were examined eleven days later. The "H" of the animal irradiated at room temperature was much plainer than the "C" of the one treated while cold. As shown in *a* and *b* of Figure 5 the histological examination also reveals the greater resistance of the skin at the low temperature.

Experiment XII will be discussed later. The animals shown in Figure 6, *a–f*, are of Experiment XIII. These animals were irradiated on the

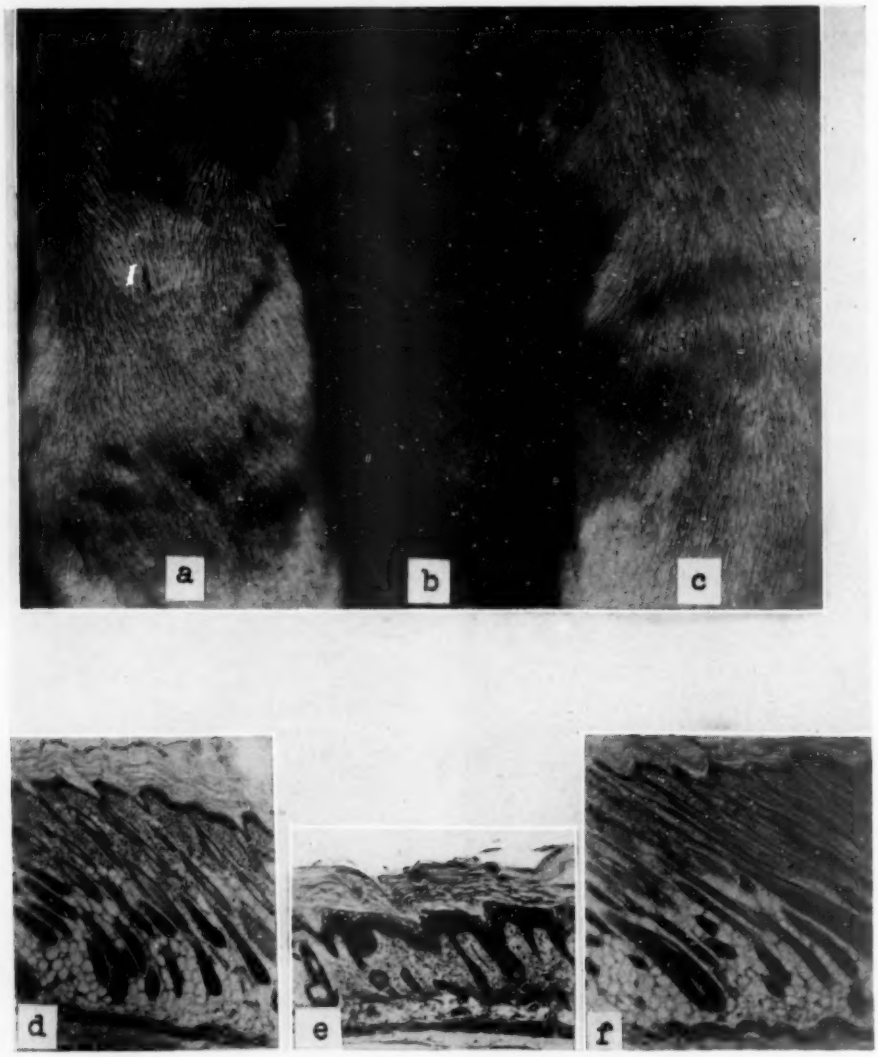

FIG. 7. Animal *a* was irradiated three different times at 0° C. Animal *b* was treated at room temperature. Animal *c* is a control (unirradiated). Sections of skin from the above animals are shown in *d*, *e* and *f*.

second day after birth with a dosage of 1,380 r. Animals *a* and *c* were at 0° C. when irradiated whereas rat *b* was treated at room temperature. It is quite evident that the injury to rat *b* is much greater than either of those irradiated while cold. These animals were irradiated on the left side but enough of the radiation penetrated through the body to affect the skin on the right side. Figure 6*d* is of the right side of the same animal shown in *a*, and the injury is so slight as to not appear in the photograph. The "H," however, of rat *e* (right side of *b*) is quite prominent. Whereas the "C" of animal *f* is visible it is not as strong as that of the rat irradiated at room temperature. The histological injury of the rat shown in *c* is limited to a thickening of the epidermis and a slight epilation (Fig. 5*c*). Figure 5*d* shows the injury to the skin of the litter-mate irradiated at room temperature. This section reveals marked hyperplasia of the epidermis, extreme desquamation, complete epilation, and extensive fibrosis. The extreme injury shown in this section and also in Figure 1*b* is no doubt related to the early age of the rats at the time of the irradiation.

In Experiment XIV a rat was irradiated at room temperature and two others were treated at 0° C. The hair over the irradiated regions of the "C" animals is seen to be sparse (*g* and *h* of Fig. 6) but that of the "H" (*i* of Fig. 6) is completely gone. Figure 5*e* is of a section of skin through the irradiated region of one of the animals treated at 0° C. and it can be seen that the injury was not extensive. The histological injury produced by the irradiation at room temperature is shown in Figure 5*f*, and definite thickening of the epidermis, epilation, and fibrosis is to be observed. Sections were made of the other animal irradiated at 0° C. and they also failed to show marked injury. It may be concluded from this series of experiments that whereas the greatest difference between the injury produced at 0° C. and at room temperature is evident in one and two day old rats, it also exists in experiments with animals three and five days of age when irradiated. It is apparent that the difference due to the change in temperature is greater than could be accounted for by individual variation and experimental error.

IRRADIATION OF ENTIRE ANIMALS AT INTERVALS

Experiment XII was designed to determine whether the difference in irradiation effect at low and high temperatures would be affected by giving several treatments instead of one. It was necessary to irradiate the entire animal in this experiment as it was practically impossible to repeat an irradiation exactly on such a small area as that of the lead stencil. The animals were given a dosage of 365 r on three different days for a total of 1,104 r on the whole body. The results of the experiment are shown in Figure 7. It can be seen that the animal irradiated at 0° C., *a*, is as large as the control, *c*, and the hair is almost as thick. The rat irradiated at room temperature, *b*, is much smaller than either of the others and the hair is practically all missing. The sections also reveal marked injury to the skin irradiated at room temperature with only a slight amount to that at ° C.

DISCUSSION

It is possible that the finding reported here is of practical as well as of theoretical interest. If results such as reported here for young rats are found to be true also for human tissues, the advantages in protecting certain regions during therapy treatment will be significant.

From a theoretical standpoint this investigation must be considered as another instance where low temperature has been found to reduce the radiosensitivity of cells. Several investigators have reported that organisms irradiated at low temperatures are more resistant than those at high temperatures (Holthusen,[6] Politzer,[8] Strangeways and Fell,[9] Packard[7]). Ancel,[1] Ancel and Vintemberger,[2] and several others, have reported failure to find increased resistance to irradiation at low temperature. Carty[3] has cited several instances where vascular as well as thermal changes have been found to affect the amount of radiation injury to such mammalian tissues as inguinal node, testicle, and ovary of rabbit, human skin, guinea pig skin and virulent rat tumors. The problem of metabolic rate and radiosensitivity is a complex one and the reader is referred to a paper by Henshaw and Francis[5] for some experiments dealing with this question, and for a review of the literature with an analysis of the problems involved.

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SENSITOMETRY OF ROENTGEN FILM AND INTERPRETATION OF SENSITOMETRIC DATA

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PART I. PRACTICAL CONSIDERATIONS

Subject: Calibration and comparison of roentgen films.

Method: Five different makes of roentgen film were exposed in an identical manner behind the rotating logarithmic step shutter to roentgen rays from the roentgenographic tube which was operated on "constant potential." Technical factors were 70 kv. average, 1.0 ma., 2 mm. aluminum filter, 250 cm., 6 seconds. Routine type of intensifying screens. Films were developed in fresh Eastman developer for 5 minutes at 65° F.

Results:

Film	Roentgens to Produce Density 1.2	Relative Speed, Density Produced by 0.0049 r	Exposure Factor*	Contrast Number	Fog
A	0.0058	1.01	1.19	0.52	0.14
B	0.0060	0.97	1.22	0.51	0.14
C	0.0071	0.89	1.45	0.49	0.18
D	0.0049	1.20	1.00	0.62	0.10
E	0.0050	1.18	1.02	0.64	0.10

* Exposure factor is the factor by which exposure time of the fastest film (in this case *D*) must be multiplied to get the same blackening (density 1.2) as that of the fastest film.

THE above sensitometric roentgen film report was recently submitted to Dr. Chamberlain by his physicist. Dr. Chamberlain was using film E in his routine roentgenography and therefore felt assured that he was obtaining the highest contrast and the maximum detail which were possible out of the films tested. Had he been using film B, for example, he would have had further tests made with other batches of films. If all tests pointed in the same direction then he would have changed the make of film that he was using in his routine work. Different kinds of intensifying screens were tested in a similar manner and the best screen to use with film E was found. The question may now come to mind, how do we know that tests of this sort furnish information which makes it possible for us to get the greatest detail in a roentgenogram? This question will be discussed below.

The silver image of a roentgenogram is produced by the development of the latent image.* The latent image is a result of the action of the fluoroscent light from the intensifying screens (and of the roentgen rays themselves to a lesser degree) on the sensitive emulsion of the roentgen film. The silver image can vary over a wide range with changes in the roentgen rays, intensifying screens, film emulsion or processing of the film. By means of a sensitometric study of the best film-screen and developing combination the roentgen technical factors may be determined to obtain the optimum detail in a roentgenogram. Sensitometry in its broadest sense is concerned not only with the sensitivity of the photographic material but with other properties as well. Some of these other properties are the quantitative measurement of characteristic responses of the film to varying amounts of roentgen rays (contrast) and a quantitative study of the action of developers (and the rest of the film processing) in converting the latent image into a visible image.

The qualities of roentgenographic film which are of most concern to the roentgenologist are the speed, the contrast and the latitude.

Speed. By the speed of a roentgen film is meant the degree of blackening produced

* A latent image is the invisible chemical or physical change which occurs in the film emulsion after exposure and before development. It corresponds to the darkened parts of the completely processed film.[18]

in the finished film by a given roentgen-ray exposure. The blackening is a combination of the effects of the roentgen rays, the intensifying screens and of the development. For example, if a "fast" type of developer is employed and the films are developed for six minutes instead of the usual five minutes the effective speed of a film might be increased by 100 per cent over what it was with a "slow" developer. This means that under the new conditions of development the roentgen-ray exposure time could be cut in half and the films would be as dark as they were before. From roentgen sensitometric tests a numerical value indicating the film speed under both conditions of development could be obtained. Their numerical values or speeds would differ by 100 per cent in this case. Such a gain in speed would be of great value to the roentgenologist provided the quality of the roentgenogram did not suffer due to the new developing methods.

Contrast. The quality or detail shown by the roentgenogram depends to a large extent on the contrast which is present. Apparent photographic contrast may be defined as the difference in photographic density between two areas of an exposed and processed film when it is evenly illuminated on one side and observed from the other. Wilsey,[23] in a paper on contrast in roentgenography, said:

> Just how plainly any detail will stand out depends primarily upon how much the contrast between it and the background or surrounding area exceeds the minimum difference which the eye can perceive. Since contrast is the basic factor controlling the visibility of details, a clear understanding of its nature and the factors affecting it is important in order to produce radiographs that will provide maximum diagnostic information.

Having determined the speed and contrast number of a series of films the best one for a given purpose may be selected. Further test films may be developed in different kinds of developers, for different lengths of time, etc., and from the speed and contrast numbers the optimum conditions for producing the highest quality roentgenogram may be ascertained.

Latitude. The latitude of a roentgenographic film is the exposure range over which the film shows satisfactory detail of the roentgen-ray shadow. If on a single roentgenogram of the chest the lung fields are exposed so as to show good diagnostic detail and at the same time the vertebral bodies show well through the cardiac shadow then the film would be said to have a great deal of latitude. If, on the other hand, when the lung fields are properly exposed for diagnostic purposes and the vertebral bodies are so underexposed that they can scarcely be seen at all through the cardiac shadow then the film has a much smaller latitude. Of necessity, the first film must exhibit low contrast and the second high contrast. The latitude then is seen to be an inverse function of the contrast. The latitude of a given film after specified development can be obtained from sensitometric studies. However, the roentgenologist must decide whether he wants high contrast or great latitude in his films and if he decides in favor of high contrast then the determination of latitude for him is of secondary importance.

In some sensitometric methods the results are interpreted directly by inspection of the processed film. Sometimes results can be obtained very quickly this way but more complete and more reliable information may be obtained by measuring photographic densities and analyzing the measurements.

PART II. THEORETICAL CONSIDERATIONS

In the quantitative sensitometric testing of roentgenographic film four fundamental steps are followed: (1) a series of known roentgen-ray exposures is made on the film (with or without intensifying screens), (2) the exposed film is processed in a given manner, (3) the resulting photographic densities are measured and (4) the data are plotted and interpreted. At this point it should be mentioned that due to unavoidable variations in the emulsion sensitivity,

to slight variations in "identically" exposed films, to small differences in development and to other factors, two test films which were supposed to have been given the same treatment will probably come out with somewhat different densities. For this reason it is important in accurate sensitometric work to expose more than one film for each test and then to average the densities for a mean value.

Exposure of the Film. When making sensitometric tests it is desirable to expose the film under conditions similar to those used in making a roentgenogram. If this is not done errors may occur in judging film characteristics from these tests. With the high milliamperage and short exposure time used in roentgenography it is very difficult to obtain exact quantitative sensitometric data. This is because any slight error in the timer makes a large percentage error in the exposure, a variation in line voltage at the instant of the exposure can neither be anticipated nor easily corrected for, and the resulting roentgen-ray beam is so heterogeneous in character that it is difficult to measure it accurately. For these reasons a method is commonly used in which the roentgen-ray technical factors differ from those employed in roentgenography but the quantity and quality of the roentgen rays reaching the film at each point are known. For example, a simple method for exposing a film is to interpose between the tube and the film to be tested, a rotating sector wheel such as that used by Bell[1] or by Jones[11] for photographic sensitometry. In our own work a rotating shutter has been used such as shown in Figure 1*A*. This shutter is rotated at a constant speed for all exposures by a small synchronous (phonograph) motor. The segments have been cut out of one-eighth inch lead sheet in such a way that each step (or ring) receives 80 per cent of the roentgen rays reaching the step outside it. The film to be tested is placed directly behind the shutter and at a convenient distance from the roentgen tube (e.g., 250 cm.). With the shutter rotating and the desired filter in place the tube is energized for the desired exposure. We set the tube current accurately at 1.0 ma. and run it constantly at the desired kilovoltage (e.g., 70 kv. constant potential). The roentgen-ray exposure is then made by opening and closing a lead shutter. Exposure time may vary from 3 seconds with intensifying screens to 90 seconds without them, depending upon the characteristics of the screens and films. The next film to be tested is then put in place of the first one (and therefore in exactly the same position in the roentgen beam) and given exactly the same roentgen exposure. Since the fluorescence (speed) of an intensifying screen varies considerably with temperature, all tests should be carried on with the cassette at the same temperature. There results a series of roentgen exposures (Fig. 1*B*) in which the total exposure time changes in a definite and known manner

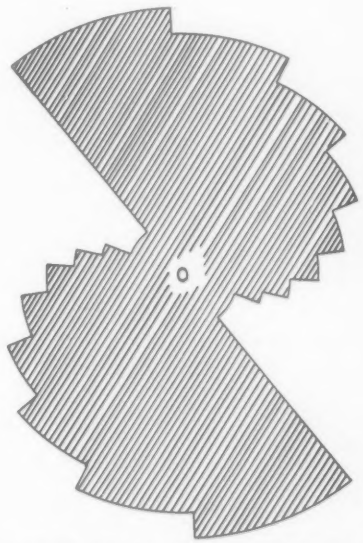

Fig. 1*A*. Plan of the lead shutter which rotates about the axis *O* (perpendicular to the plane of the paper). The shutter is cut from 1/8 inch lead sheet and is stiffened by a sheet of aluminum. The sections have been cut out so that when the shutter rotates and a roentgen-ray exposure is made, a series of concentric rings is produced on the film as shown in Figure 1*B*. Each ring, progressing inward, receives 80 per cent of the roentgen rays falling on the outer ring next to it. The exposures therefore vary logarithmically and the device is called a rotating logarithmic step shutter.

from area to area of the exposed film, corresponding to the angular openings of the sector wheel. The quality of the radiation remains constant for all exposures. This method is desirable because of these features.

The objection may be raised that the conditions are not similar to those under which a roentgenogram is made. (1) The intensity of the roentgen rays is less than that used in most roentgenograms. Low intensity is necessary in making the tests to permit obliteration of shadows of moving shutter edges and to allow more accurate exposure timing. (2) The quality of the roentgen rays reaching different parts of the film changes from point to point in a roentgenogram. (3) The exposure for a roentgenogram is continuous (that is, 120 pulses per second for a full wave rectified machine) for the given time, while for the sector wheel it is broken up into a series of flashes (in our case 16 per second). The latter type of exposure may produce a different amount of blackening of the film (especially with intensifying screens) due to the intermittency effect.[22] One continuous exposure produces, in general, a greater blackening of the film than a series of exposures of equal total time. (For example ten one second exposures may produce less blackening than one ten second exposure of the same intensity.) Additional testing is therefore necessary to establish the correlation of data obtained with the sector wheel shutter and that obtained with routine roentgenographic technique. We have made such tests and have found an intermittency effect when intensifying screens were used but for practical comparisons between films the correlation is satisfactory.

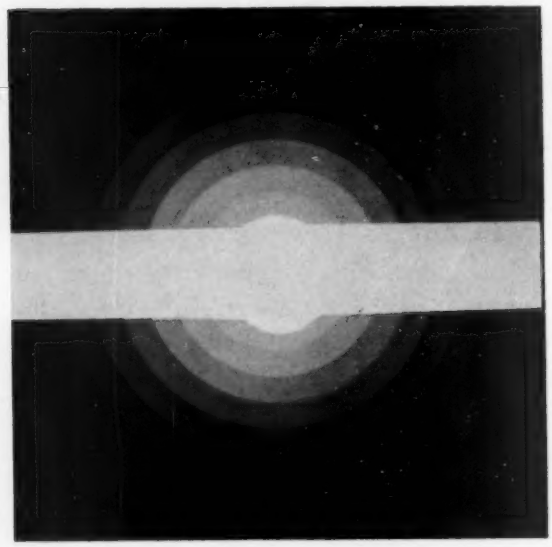

FIG. 1*B*. Roentgen film exposed behind the rotating logarithmic step shutter shown in Figure 1*A*. Exposures vary as described in the legend of Figure 1*A*. The white band across the center is the roentgen-ray shadow of the metal strip which supports the bearings of the shutter.

Webb[17] has shown that if the speed of rotation of the sector wheel exceeds a certain critical value (about 16 flashes per second), the photographic effect through any aperture of the sector is the same as that of the continuous exposure of the same average intensity applied for the same time. In his experiments exposures of *light* (wave length 4360 Å) were used with both negative and positive photographic emulsions. Bell,[1] using roentgen rays and films *without intensifying screens*, found no evidence of intermittency effect when roentgen rays excited by constant and by pulsating voltages were compared.

To do away with any possible intermittency effect, the lead sector wheel is sometimes rotated slowly for one revolution. Another arrangement accomplishing the same result consists of a reinforced lead plate with slots accurately milled out from 1 mm. to 1 meter in length (the intermediate steps being cut out on a logarithmic ratio). This slotted plate runs on a track or trolley at a constant but adjustable speed past the cassette. The exposure is made while the shutter is in motion, the cassette being entirely protected at the beginning and at the end of the travel. This type of shutter has been used by Jones[10] for photographic sensitometry.

The aluminum step ladder has been advocated by White[20] and others[2] because in

such tests the conditions are nearly identical to those under which a clinical roentgenogram is made. Furthermore, as has been shown by Hodge, *et al.*,[8] the spectral absorption of aluminum parallels that of bone. Of course, there is considerable difference when soft tissues are involved. In the method used by White a ladder ranging from $\frac{1}{8}$ to 1 inch in thickness in steps of $\frac{1}{8}$ inch is placed upon the film. Three roentgen exposures of the ladder are made in such a way that the exposure of each differs by a factor of two in intensity only. The conditions of exposure, therefore, are nearly identical to those of clinical roentgenography. Due to the heterogeneous radiation the numerical values obtained from aluminum absorption will not apply to all machines. By assuming that areas of the same film have received equal exposures when the resulting densities are equal, after the film has been uniformly processed, it is possible to determine in arbitrary roentgens how much roentgen ray falls on each step of the film. From these data a density-exposure curve may be drawn. But areas of equal density have not necessarily received an equal number of roentgens, since the quality of the rays through various thicknesses of aluminum changes from step to step and the sensitivity of the film is not the same for all qualities of roentgen rays, particularly when intensifying screens are used. In spite of the above objection, the aluminum step ladder method is very useful for comparing different makes of film, the effects of various methods of processing, etc.

Processing of the Film. After the roentgen film has been given a series of defined exposures, it is developed under standardized conditions. High accuracy in standard development is very difficult to attain. To obtain the same degree of development of films in two or more laboratories is still more difficult.

The difficulty of standardization of development arises largely from two factors. In the first place the potency of the developer varies with its temperature and its chemical composition (its formula and the impurities in the water used in mixing the formula). These factors may be taken care of by calibrating the developer as described in previous papers.[3,4,7] For calibration in sensitometry several film calibration strips should be developed simultaneously and the average density of each step used as the working value. In the second place the degree of development may vary from point to point on a single film due to the weakened developer diffusing from above downward over the emulsion surface.[22] As a result of this action the lower part of an exposed film is less developed than the upper part. To combat the latter effect elaborate methods of stirring and of applying the developer to the film have been devised. The developer may be continuously spread over the film by means of wide soft brushes. With the double emulsion of roentgen films it is difficult to use brushes. Where the conditions are such that practically full development of the image is produced in the normal developing time, errors from this source are greatly diminished. Good results for routine tests may be obtained by carefully mixing fresh developer from ready measured chemicals supplied for this purpose by a reliable manufacturer. The solution is allowed to stand for at least twenty-four hours and is brought to a given temperature (65° F.). (Solutions used immediately after mixing are sometimes not uniform in their action.) The film is then allowed to hang in this solution for a given time and is quickly washed and placed in the fixing bath. If a strip of film is used it is mounted in the hanger so that the length is horizontal. From the fixing bath it is washed and dried in the usual manner.

Measurement of Photographic Density. The finished film is placed on the densitometer[5,6,13,14] or photometer[22] and the density* of each area is measured. We measure corresponding areas on the film which

* A simple explanation of the physicist's method of expressing the density of a roentgen film:

1. Let us assume a film has such a degree of blackness that when light of intensity 1.0($=I_0$) falls upon it, the transmitted light ($=I_t$) has an intensity of 0.1 (in other words, nine-tenths of the

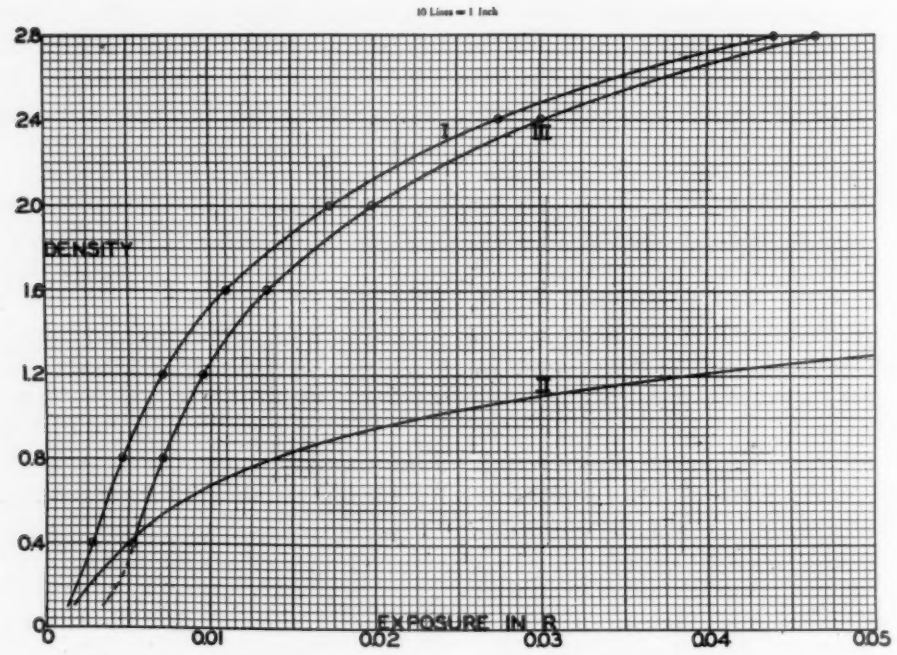

FIG. 2. Curves showing the relation between photographic density of the processed film and exposure in roentgens. The data were obtained from films with intensifying screens (Patterson par-speed) exposed at 70 kv. constant potential through 2 mm. of aluminum filter and the rotating logarithmic step shutter. Curve I is for normal development, II is for identical roentgen-ray exposure but one-half development time and III is a hypothetical curve obtained by moving I to the right.

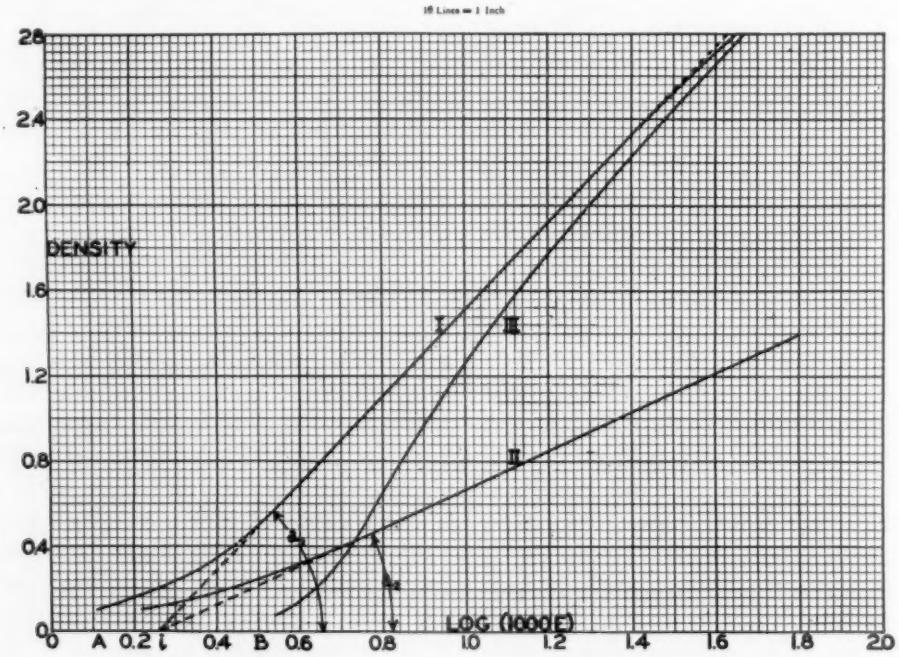

FIG. 3. Characteristic or *D*-log *E* curves drawn from the data of the curves in Figure 2. The exposure is measured in roentgens. Plotting log (1000 *E*) instead of log *E* merely shifts the decimal point of the abscissae three places and does not affect the shape of the curves.

are in contact with identical areas of the intensifying screens. In this way differences in intensification factor over the surfaces of the intensifying screens are minimized and corresponding areas of the roentgen-ray field are used in each case. Furthermore, differences in development resulting from data is to plot the density against the exposure in roentgens (or arbitrary roentgens if the step ladder method is used). This has been done in Figure 2 in which films I and II were exposed equally to roentgen rays at 70 kv. constant potential, 2 mm. aluminum filter, with intensifying screens, but I was

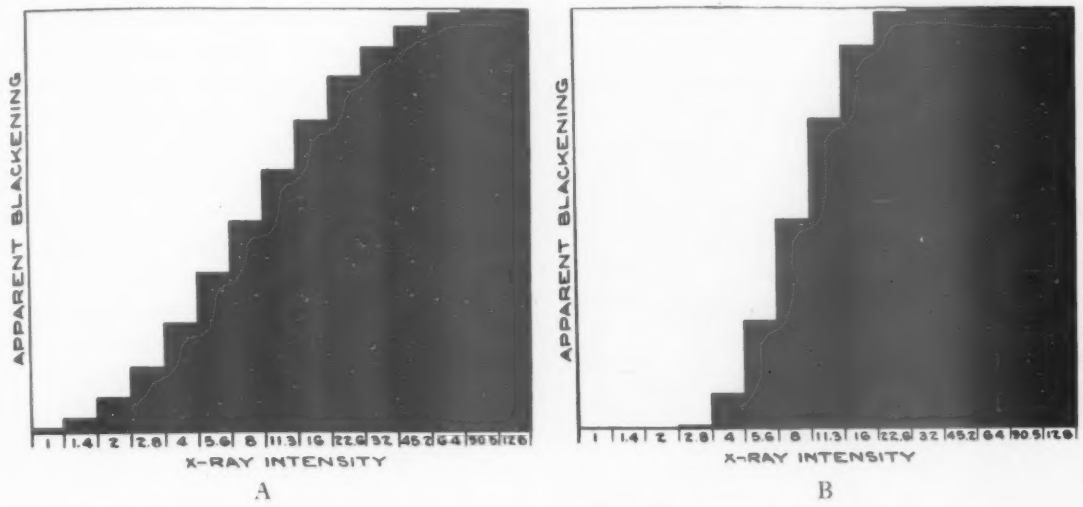
APPARENT BLACKENING
1 1.4 2 2.8 4 5.6 8 11.3 16 22.6 32 45.2 64 90.5 128
X-RAY INTENSITY
A
APPARENT BLACKENING
1 1.4 2 2.8 4 5.6 8 11.3 16 22.6 32 45.2 64 90.5 128
X-RAY INTENSITY
B

FIG. 4. Reproduction of a figure from Wilsey's article. Ratios of roentgen-ray intensity are plotted as abscissae and the varying degrees of resultant blackening as perceived by the eye as ordinates. *A*, for a roentgenogram of moderate contrast; *B*, for a roentgenogram of high contrast.

weakened developer diffusing from above downward are largely compensated for because all films are placed in the developing tank with the corresponding ends upward. After the densities are measured the resulting values must be analyzed. Interpretation and analysis are often facilitated by plotting the data in graphic form.

Plotting the Characteristic Curves. One way to study graphically the sensitometric developed the normal time while II was developed half of this time. For reasons given below, data are not usually plotted in this way. Instead, the density is plotted against the logarithm (base 10) of the exposure, as in Figure 3. The data from the curves of Figure 2 were used in Figure 3. It will be noted that the toes of the curves in Figure 3 are not as steep as those in Figure 2 and that there is more nearly a straight line portion at the medium and higher densities in Figure 3. These properties have advantages when the curves are analyzed.

A type of logarithmic plotting has been illustrated by Wilsey,[23] as shown in Figure 4. The photographic blackening produced by each intensity as judged by the eye in viewing the roentgenogram as a whole (apparent blackening) is represented by the height of the column. A curve drawn through the centers of the steps would be

incident light is absorbed by the film). The physicist records the density of such a film as $D=1.0$ ($D=\log_{10} I_0/I_t=\log_{10} 10=1$).

2. If now another piece of the same film is superposed upon the first, the emergent light will be 1/100 of the incident beam instead of 1/10, because the degree of blackness in the particular film is, as stated above, such that each layer of it cuts incident light down to 1/10. The first layer reduces light to 1/10 of its original value and the second layer reduces it to 1/10 of 1/10 or 1/100. In the physicist's formula for density, I_t (transmitted light) is 1/100 of I_0 (incident light) and therefore he records the density as $D=2$. ($D=\log_{10} I_0/I_t=\log_{10} 100=2$).

Hurter and Driffield[9] stated that the density is directly proportional to the mass of silver per unit of the processed film. More recently Sheppard and Ballard[16] have shown that there is considerable variation in the ratio of silver to density, depending on both exposure and degree of development.

an *apparent* density vs. logarithm exposure curve or a $D_a - \log E$ curve.

Another way to plot the data of sensitometric studies in which a step ladder has been employed is to plot the thicknesses of the ladder as abscissae and the densities as ordinates. This is not a truly logarithmic curve since each successive step absorbs a smaller proportion of roentgen rays than

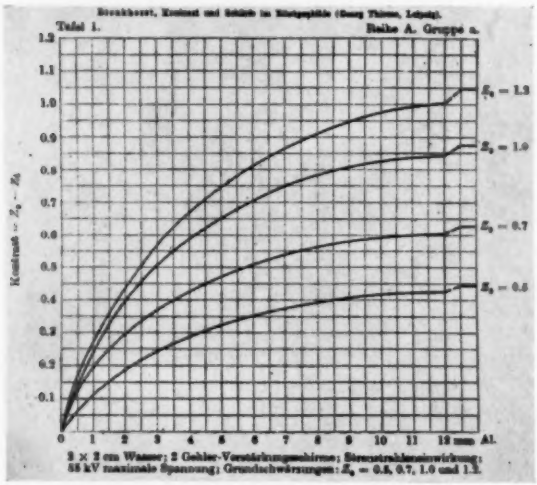

FIG. 5. Bronkhorst's method[2] of plotting contrast against thickness in millimeters of aluminum step ladder penetrated by the roentgen rays. Z_0 is the basic or greatest density produced on the film (zero aluminum) less the processing fog. Z_b is the density of the film under the selected step of the test ladder.

the one before it because of the hardening effect on the roentgen rays as the ladder material is traversed. Bronkhorst[2] plots what he terms "Kontrast" against thickness of aluminum (Fig. 5). He defines "Kontrast" as $(Z_0 - Z_b)$. Z_0 is the basic density, that is, the greatest density (zero aluminum) less the processing fog. Z_b represents the densities of shadows of steps of the test ladder. This is practically the density curve mentioned above, but reversed, since in this case for the smaller thicknesses of aluminum the curves are lowest instead of highest.

The logarithmic curve, which is characteristic of roentgen film emulsions, has a rounding toe at the lower densities, becomes a straight line (or nearly so) for a considerable range along the middle densities and tapers off at the higher densities to a maximum density. The maximum density is obtained when all of the silver in the emulsion contributes to the blackening. The straight portion in such a curve, in photography, is called the "region of correct exposure" since throughout this exposure range, density is directly proportional to log E. In a photograph the negative will thus render correctly the proportional object brightness when the exposure is adjusted to be within this range. In diagnostic roentgenograms it is desirable to emphasize small differences in roentgen-ray opacity as much as possible. This is accomplished when the contrast is highest and, as will be shown below, this occurs at the steepest part of the D-log E curve. From the shape of the curve it will be seen in general that the straight line part is also the steepest part and that the roentgenographic exposure should lie within this range.

The roentgenogram is studied visually and therefore the density range should be that for which the unaided eye can best detect small differences in density. For chest roentgenograms under ordinary viewing conditions this density range for a person with normal vision lies between 0.5 and 1.5. Any areas of the film which are under suspicion should lie within this range. In a chest roentgenogram, however, there are relatively large areas of low density in the heart and diaphragm shadows and the illumination through these impairs the ability of the eye to readily distinguish detail in the areas of density above 1.5. In types of roentgenograms which contain no areas of low density, the upper limit of density for good visualization probably approaches 2.0. Bronkhorst[2] states that for best viewing conditions a basic density within the object shadow of about 1.2 should be obtained. This makes it possible for the observer to perceive smaller differences clearly and accurately. Characteristic or D-log E curves of roentgen film show

that this density range (0.5–1.2) falls on the toe and at the beginning of the straight line portion of the curve. Measurements made only along the straight portion of the curve do not represent fully the conditions usually found in roentgenograms.

Correction for Fog. When studying the characteristics of a film emulsion it is customary to make a correction for fog. Fog may be considered as any density which arises from sources other than the roentgen-ray exposure in the sensitometer. It may be due to chemical processes involved in making the emulsion (or acting on it after it is made and before it is used), to unintentional light or roentgen-ray exposure at any time during the handling of the material, to mechanical effects or to fogging agents in the developer. Hurter and Driffield[9] (in photographic sensitometry) made a correction for fog by measuring the density of an unexposed area which had been subjected to the same development as the sensitometric strip to which the correction was to be applied. They then subtracted this value from all of the measured densities. Subsequent experimental work has shown that the fog overlying the lower densities is appreciably higher than that overlying the higher densities[15] and therefor this procedure may lead to very erroneous conclusions as to the sensitometric characteristics of the material. Wilsey[21] has proposed a formula which theoretically should give good results but which was not intended for practical sensitometric testing.

From the roentgenologist's point of view it may be of importance to correct for film fog when determining the speed of the film. If this is not done an inferior film with excessive inherent fog would appear to be faster than a similar but better film without fog. As far as contrast is concerned, excessive fog is very detrimental. By measuring the film densities as they are (that is with the fog), a truer picture of the roentgenographic contrast is obtained.

Interpretation of the Plotted Data. It is next necessary to determine from the graphs what the characteristics of the film will be when used in making roentgenograms. From a practical point of view the characteristics which are of most concern to the roentgenologist may be called the speed, the contrast and the latitude.

The response (blackening) of the film may be recorded numerically in at least two ways. One of these is to record the photographic density resulting from a roentgen-ray exposure of given amount. When such numerical values of density (of different films) are compared, the relative merits of the films are obtained but the difference in roentgen-ray exposure required to produce equal densities is not known. Therefore if one film is to be used in place of another, the correction factor for exposure cannot be obtained. The other method of recording speed overcomes this objection. In this method the number of roentgens of a given quality of radiation required to produce an arbitrary density, say 1.2, is found. When the speeds are recorded in this manner the relative exposures required to produce the same darkness of film are readily obtained. If films are to be compared as to merit the fog must be taken into account, as described above.

It must be kept in mind that the film with the smallest numerical value (r) is the fastest. Speeds as given by this method are comparable only for roentgen rays of the same quality. This is illustrated by the fact that one film which was tested with intensifying screens on constant potential roentgen rays required 0.0058 r at 70 kv. with a 2 mm. aluminum filter to produce a density of 1.2 while the same film and screens required 0.0244 r to produce that density at 40 kv. and no filter. It has been shown that a large part of this apparent difference in speed is due to the fact that the bakelite and front intensifying screen in the testing cassette absorb a proportionately greater amount of the 40 kv. roentgen rays than of the 70 kv. roentgen rays.

When the sensitometric data are plotted as in Figure 2 with densities as ordinates and exposures (r) as abscissae or as in Figure 3 with log E as abscissae then by

inspection the highest curve (the one to the left) represents the fastest or most sensitive film.

For a more technical study of the physical characteristics of emulsions the speed is usually expressed in a different manner. Use is made of the term "inertia" which may best be explained by reference to Figure 3 showing a typical density—log E curve of a roentgen film with intensifying screens. In this case the density of the processed film is plotted against the logarithm of 1000 times the exposure in roentgens. The toe of curve 1 lies between A and B. At B the curve straightens out and if it had been carried far enough up it would flatten out to reach a maximum density of perhaps 6.0 (depending on the development).[24] Increase in exposure beyond this point would not increase the resulting density. If the straight portion of this curve is extended down to reach the log (1000 E) axis it will intercept it at some point i (log (1000 E) = 0.26). The value of E (in this case 0.0018 r) at this point is called the *inertia*, i. Since a material of high sensitivity (a "fast" film) has a low inertia value, and vice versa, it is necessary to take the reciprocal of the inertia in order to obtain a value which varies directly with sensitivity. The absolute values obtained by doing this may be inconvenient numbers so a constant k, chosen arbitrarily so as to give a series of convenient numbers, is sometimes used as a multiplier. The speed determined in this way may be defined as

$$S = \frac{1.0}{i} k.$$

The shape and position of the characteristic curve depend on the development conditions as is illustrated by curve II of Figure 3, in which the film was given one-half the development time of film 1. In this case both the straight line portions of the curves when extended happen to intersect the log (1000 E) axis at i. Therefore, the speed expressed in terms of inertia is the same for both cases. In general, this is certainly not the case as the straight lines extended may also intersect above or below the log E axis. However, the value of the speed thus obtained indicates more nearly the characteristic of the emulsion itself and is therefore used in emulsion research. For practical roentgenography, however, it is obvious that the film developed the shorter time would appear lighter and would therefore appear to be slower.

Contrast. Contrast is the difference in photographic density between two areas of a processed film. If the density of one area is D_1 and that of another area which is less dense is D_2 then the contrast between the two areas is $D_1 - D_2$. If I_0 is the intensity of light incident upon the film and I_1 is the intensity of the transmitted light through area No. 1, then the density is $D_1 = \log_{10} I_0/I_1$. Likewise for area No. 2, $D_2 = \log_{10} I_0/I_2$. Then $D_1 - D_2 = \log_{10} I_2/I_1 =$ contrast between area No. 1 and No. 2. Just how small a difference in density or contrast in a roentgenogram is perceptible depends upon the conditions under which the roentgenogram is viewed and the character of the transition between the areas being studied. If this transition is represented by a sharp boundary between two adjacent areas then the difference is more readily observed than if one area gradually fades into the other. Under the best conditions of illumination, and with sharp boundaries, Wilsey estimates that the minimum difference in density which can be seen is about 0.01, which corresponds to a difference in brightness of about 3 per cent.

In testing roentgen films it is desirable to determine the ability of the film to distinguish between small differences in exposure. A film which produces relatively large differences in density for small changes in exposure would be said to have high contrast or to be a contrasty film. The word "contrast" used in this sense refers to a characteristic of the film emulsion. The contrast of an emulsion of course depends also upon the processing. How then can the contrast or the ability of a film to distinguish small differences in exposure be ex-

pressed in convenient form so that two or more films can be compared?

Referring to Figure 2 it is seen that for film No. 1 at density 1.0 a *change* in roentgen rays of 0.001 r produces a change in density of 0.16 whereas for film No. II a change in roentgen rays of the same amount changes the density only by 0.02. This is equivalent to saying that at density 1.0 the slope of curve 1 is greater in this proportion than that of curve II. The contrast under the conditions of curve 1 (full development) might be expected therefore to be greater than under the conditions of curve II (half time development). In this case it is indeed found to be true, but when the sensitometric data are plotted *in this manner* (instead of in the manner of Fig. 3) the conclusion cannot be drawn in general, that around any particular density the steeper curve represents the film which will produce the roentgenogram with the highest contrast nor that curves of equal slope produce equal contrast. This is because the speed of the film must be taken into account as can be shown by the following example. Consider a case in which there is a moderately opaque nodule surrounded by homogeneous tissue. In roentgenographing this part assume that the nodule plus the surrounding or overlying tissue absorbs 87.5 per cent (or 7/8) of the roentgen rays passing through it, and that the surrounding tissue only, absorbs 75 per cent (or 6/8) of the incident roentgen rays. What will be the difference in density or the contrast between the nodule and the surrounding area? If an exposure is made such that the density on the film of the surrounding tissue shall be 1.2, then for film 1 0.007 r must reach the film (or 0.028 r is incident on the body, neglecting the inverse square law). The roentgen rays passing through the body and the nodule is therefore 12.5 per cent (or $\frac{1}{8}$) of 0.028 r or 0.0035 r and the density shown on the film is 0.60. The contrast between the two is therefore 1.2−0.60 = 0.60.

Now consider that a second film is used in place of No. 1 and that the characteristic curve of this film is as shown in curve III. The latter curve is a hypothetical curve and was obtained merely by shifting curve 1 to the right. It thus represents a slower emulsion. The two curves are seen to be parallel (tangents drawn at equal densities are parallel). At first sight the conclusion might be made that the contrast as shown on the roentgenogram would be the same since equal increments of exposure produce equal changes in density. This is not the case for to get a density of 1.2 for the surrounding tissue with film III, 0.0095 r will be required at the film. Therefore 0.038 r (that is 4×0.0095 r) must be incident on the body of the patient. Then 12.5 per cent (or $\frac{1}{8}$) of 0.038 r or 0.00475 r will pass through the patient and the nodule, to produce a density of only 0.26. The contrast between the nodule and its surrounding tissue in this case is 1.2−0.26 or 0.94. Thus the contrast shown by film III is considerably greater than that shown by film 1 although the slopes at equal densities are the same. This discrepancy arises from the fact that it is incorrect, when data are plotted in this form, to assume that the contrast is proportional to the slope. It can be shown analytically that if the tangents of such curves (over the density range under consideration) pass through the origin (0.0), the contrast produced by the films will be the same, regardless of the slope. This is because the speeds of the films differ. If the tangents drawn at a given density are parallel the one farthest to the right (the slowest film) will produce the highest contrast.

A Simple Method of Expressing Contrast. From the sensitometric data as illustrated in Figure 2 (or the data obtainable from Fig. 3) it is possible to define a "contrast number" which will indicate the relative contrast merits of the films tested. This may be defined as follows:

$$\text{Contrast Number} = D_1 - D_i$$

where D_1 = an arbitrary density (1.2 is a practical value) which is produced by a known amount of roentgen radiation. The amount of roentgen rays to produce D_1 is

found from the density-exposure curve. $D_{\frac{1}{2}}$ = the density produced by $\frac{1}{2}$ of the roentgen radiation required to produce D_1. This is also found from the density-exposure curve.

If the density D_1, about which the contrast number is to be figured, is 1.2 then the contrast number is given by:

$$\text{Contrast Number} = 1.2 - D_{\frac{1}{2}}$$

where $D_{\frac{1}{2}}$ is the density produced by $\frac{1}{2}$ of the roentgen radiation required to produce a density of 1.2. For example, in curve 1 of Figure 2 an exposure of 0.007 r is required to produce a density of 1.2. One-half of this much roentgen radiation (0.0035 r) produces a density of 0.60. The contrast number is therefore: C.N. = 1.2 − 0.60 = 0.60. A density of 1.2 is about that found in the lateral lung field of an average adult chest roentgenogram.[19] The density on the same roentgenogram in the area where the clavicle and first rib overlap is about 0.52. If this film had the characteristics of curve 1 (Fig. 2), it is seen that the difference in roentgen rays required to produce such a change in density is 0.007 r − 0.0033 r or a difference of roughly one-half. The contrast number as computed above is therefore representative of roentgenographic conditions.

TABLE I

D_1*	Roentgen Rays for D_1	$\frac{1}{2}$ Roentgen Rays for D_1	Density ($D_{\frac{1}{2}}$) for $\frac{1}{2}$ Roentgen Rays for D_1	Contrast Number
0.8	0.0046 r	0.0023 r	0.30	0.50
0.9	0.0052	0.0026	0.36	0.54
1.0	0.0057	0.00285	0.42	0.58
1.1	0.0064	0.0032	0.51	0.59
1.2	0.0070	0.0035	0.60	0.60
1.3	0.0080	0.0040	0.68	0.62
1.4	0.0088	0.0044	0.76	0.64
1.5	0.0098	0.0049	0.86	0.64
1.6	0.0108	0.0054	0.96	0.64
2.0	0.0170	0.0085	1.36	0.64
2.4	0.0275	0.01375	1.82	0.58
2.8	0.0440	0.0220	2.22	0.58

* D_1 = the density about which the contrast is measured.

It is interesting to determine the variation of the contrast number with the basic density chosen. This would indicate at which basic density the roentgenogram should give the highest physical contrast. (The highest physical contrast does not necessarily mean the highest visual contrast because when the film is observed, the lighting conditions on both sides of the film, the color of the viewing light, and the individual's eyes must be taken into consideration.) Using the method described above, Table 1 is obtained from curve 1 of Figure 2.

It will be seen that as D_1 increases the contrast number at first increases, stays at a maximum over a considerable range and then decreases. It approaches zero as the maximum density attainable by the film is reached.

Under many conditions of viewing roentgenograms, small differences in densities cannot be distinguished if the areas under consideration have densities greater than 1.5. By increasing the illumination this may be raised to about 2.1. In most roentgenograms it would be possible to increase the contrast, and therefore the detail by increasing the exposure to a basic density of 1.8. The illumination would then be increased to correspond (i.e., about twice the intensity of illumination). In this case it would be even more essential to cut out the glare from any portion of the viewing box surface which is not covered by the film.

Another method of expressing the contrast of the emulsion has been used principally in photography and, to a degree, in roentgen-ray sensitometry. This makes use of the slope of the D-log E curve, as in Figure 3. For the straight line portion the slope is constant and may conveniently be expressed by the angle "a" subtended by this line and the log E axis. The tangent of this angle is called gamma and is the proportionality factor giving the relation between a given log E difference and the cor-

responding density difference. It is proportional to the contrast and is usually used as a means of expressing the contrast of a photographic emulsion. It must be remembered that gamma gives information pertaining only to the straight line portion of the curve and tells nothing of the contrast characteristics of other portions of the *D*-log *E* curve. Also the angle "a" cannot be read directly off the curve unless the coordinates have been plotted to the proper scale.

The slope of the *D*-log *E* curve is proportional to the contrast of the film emulsion independent of the speed. The curve having the steepest slope represents the film which will produce the highest roentgenographic contrast.

Latitude. Latitude may be determined graphically directly from the plotted curves. In Figure 3 curve 1, the latitude is from about log (1000 *E*) = 0.44 or *E* = 0.00275 r (density = 0.4) to more than log (1000 *E*) = 1.6 or *E* = 0.04 r (density = 2.7). For practical purposes the latitude would be less than this because under ordinary conditions the eye cannot detect small density differences above a density of about 1.8. For film 1 of Figure 3 this is given by log (1000 *E*) = 1.14 or *E* = 0.0138 r. Latitude may be expressed in the form of the ratio of the maximum to the minimum exposure giving satisfactory contrast under ordinary viewing conditions. Difficulty arises due to the fact that these points are not definite. In the examples given above the latitude of film 1 as shown in Figure 3 is 0.04/0.00275 = 14.5 and the latitude for ordinary diagnostic work is 0.0138/0.00275 = 5.0.

Since the useful diagnostic range of a film lies between fairly definite density limits it becomes evident that the higher the contrast of a film the less its exposure latitude. Therefore if the part to be roentgenographed has a wide spread of total tissue densities there is danger, when a very contrasty film is used, of losing visibility of details rendered in the lower and higher density levels. Contrast is lost in the lower densities because of the characteristic response of the film emulsion. It is lost in the higher densities because the ordinary illumination used in viewing the film does not allow the eye to distinguish existing physical differences. It remains true, however, that to obtain maximum detail of a given anatomical part or pathological lesion the most contrasty film should be used and the roentgen-ray exposure adjusted to bring this area within the diagnostic range of density. This requires accurate technique in exposing and in developing the film.

SUMMARY

In Part I practical considerations of roentgen-ray sensitometry are discussed and the points of most interest to the roentgenologist are outlined.

In Part II the theoretical aspects of roentgen-ray sensitometry and the interpretation of sensitometric data are considered. It is concluded that a rotating sector wheel of the type described gives results within the limits of accuracy required for the routine testing of roentgenographic films and of intensifying screens. Uniform film processing is a difficult problem and one of great importance in sensitometric work. Development of film strips placed in fresh developer with the length horizontal and developed without agitation is satisfactory. Average densities of several "identical" strips should be obtained. For interpretation of the sensitometric data directly from a graph the best method is to plot photographic density against logarithm of exposure. A method of expressing film speed, contrast, and latitude by numerical values is explained. The film having the highest contrast number, when expressed in this way, is the film capable of showing the smallest differences in roentgenographic opacity. The relationship between roentgenographic detail and contrast is brought out.

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A COMPARISON OF CERTAIN ASPECTS OF 200 AND 400 KILOVOLT RADIATION

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A BEAM of radiation emitted by the target of a roentgen tube is composed of roentgen rays of many different wave lengths. The minimum or shortest wave length, that is, the hardest or most penetrating portion of the beam, is a function of the maximum voltage between the target and the filament of the roentgen tube. The intensity of this portion which contains the shortest wave length is, however, practically zero. The intensity of the radiation at other wave lengths is not simply determined, but depends on the material from which the target is constructed, the filter utilized, and the wave form of the voltage which is effective in drawing the electrons from the filament to the target, the last two factors being the most important.

The most efficient practical method of describing the quality of such an heterogeneous beam is by means of an absorption curve made by interposing filters in the path of the rays and measuring the successive decreases in ionization. A curve made in this manner may then be compared with standard absorption curves and the equivalent constant potential of the beam determined.[7] The quality may also be described by stating the absorption coefficient, the effective wave length (the wave length of a monochromatic beam of radiation which would be absorbed in the same manner in a given filter) or the half-value layer (thickness of filter necessary to decrease the beam to one-half of the original intensity). These last three methods described are useful in many cases, but have been shown to give ambiguous results.[5]

It is a well known fact that roentgen rays, on passing through an absorbing material such as tissue, become "softened"; that is, the percentage of the longer wave length components is increased. This "softening" is due largely to the Compton effect, which is the name given the phenomenon which causes the wave length of a quantum to increase when the quantum is "scattered" or deflected.

This change in quality of radiation in passing through tissue was realized to be an important factor in deep radiation therapy, and was investigated by Quimby and McNattin[6] for radiation generated by 200 kv. (peak). These workers developed a method of measuring the quality of radiation at any depth in a paraffin phantom by means of copper shells placed around an ionization chamber. It is their method which was utilized in the experimental work which is to be described.

There has been a tendency to increase the hardness of roentgen rays which are used for the treatment of deep-seated lesions. The chief reason for this increase in voltage is the corresponding increase in the depth dose. There are probably accompanying changes in the relative radiosensitivity between neoplastic and normal tissues, but this is at the present time very uncertain.

The question of depth dose has been studied from both the physical and biological viewpoints. Failla, *et al.*[1] have published comparisons of the absorption of 200 and 700 kv. (peak) radiations as indicated by ionization. Henshaw and Francis[3] have reported on the depth dose as measured by the effect on wheat seedlings and *Drosophila* eggs at 165 and 650 kv. (peak). The latter work shows that the biological depth dose is considerably less than the ionization measurements indicate. Further work by these authors[4] proves beyond doubt that relative radiosensitivities can change with change in quality, and further show that for certain biological test objects the depth dose

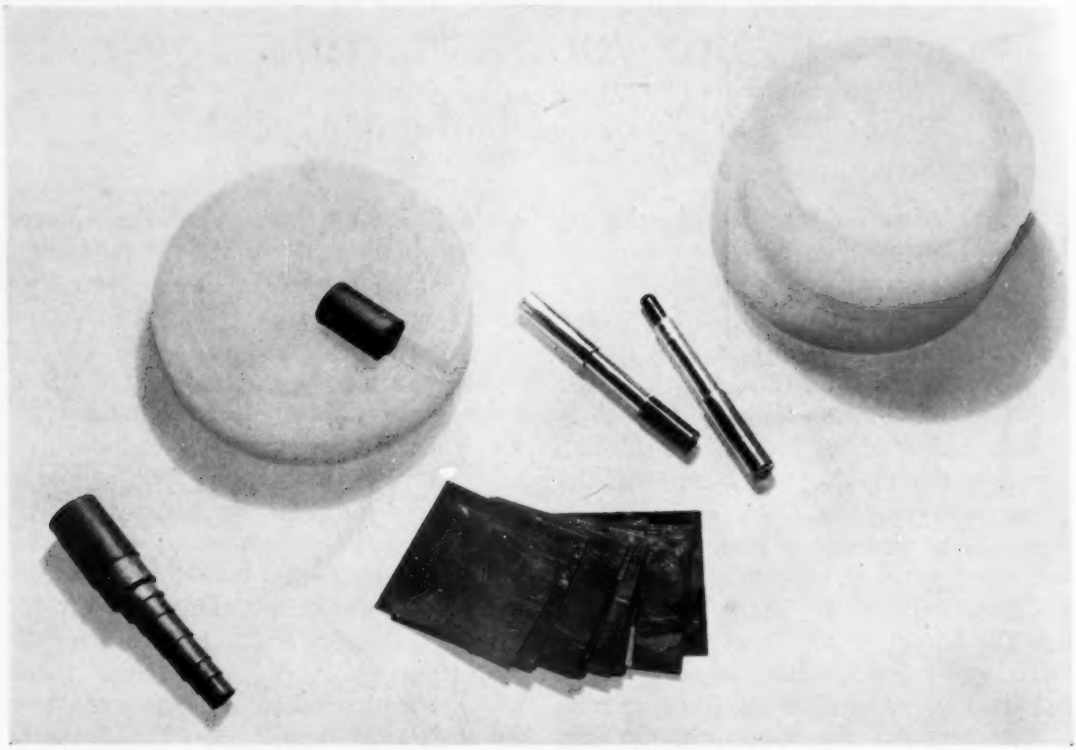

FIG. 1. Paraffin phantom, flat filters, "thimble" filters and ionization chambers.

can be greater or less than ionization measurements indicate, depending on the wave length of the incident radiation.

For this reason, it is important to study the quality of the incident radiation and any changes in its quality caused by scattering, and to determine how these changes in quality are affected by changes in the generating voltage. Accordingly, an experimental study was carried out in order to compare the changes in quality of 200 and 400 kv. radiation in passing through tissue. It is felt that the results given will become increasingly useful in the future as further data on differential effects is obtained. It was pointed out that this study has been previously made by Quimby and McNattin[6] for radiation generated by 200 kv. (peak). It was thought best, however, to repeat this work at 200 kv. as a check on the apparatus and method as there were several uncontrollable differences between the apparatus used by the above investigators and that used by the author.

EXPERIMENTAL PROCEDURE

A paraffin wax phantom was constructed, using paraffin having a specific gravity of 0.9. The phantom, together with the "thimble" type copper filters, the flat copper filters, and the condenser type ionization chambers, is shown in Figure 1.

The source of 200 kv. radiation was a General Electric type XPT, 220 kv. water-cooled tube. This tube was mounted in a lead lined box having a 0.25 mm. copper filter mounted permanently in the portal. This filter, plus the 0.2 mm. equivalent copper inherent filtration of the thick-walled tube, made a minimum filtration available of 0.45 mm. copper. The tube was supplied with 20 ma. of full wave mechanically rectified current. The voltage across the tube measured 210 kv. (peak) with the conventional sphere gaps.

The source of 400 kv. radiation was an oil-cooled General Electric 400 kv. sealed tube immersed in an oil drum. The inherent filtration of the tube plus the oil and

the portal was equivalent to approximately 3.0 mm. of copper. This tube was supplied with 5 ma. from a Villard circuit rectifier manufactured by the Kelley-Koett Company. The voltage was factory calibrated at 400 kv. (peak).

A comparison of the quality of these sources is shown in Figure 2, which gives

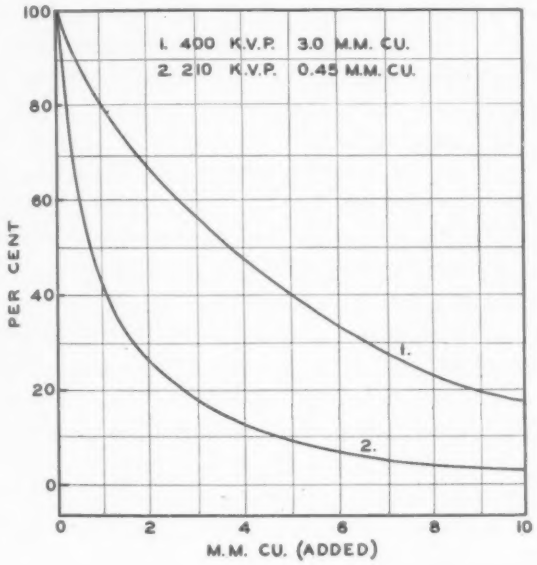

Fig. 2. Curve giving comparison of the two sources of radiation used.

absorption curves for these radiations. The half-value layers are 0.7 mm. copper and 3.6 mm. copper for the 210 and 400 kv. (peak) respectively.

The ionization measurements necessary to plot an absorption curve must be taken with great care, as the size and placement of the diaphragms in relation to the roentgen tube and the ionization chamber is most important. This is important because slight variations from the correct values may lead to large errors, especially at 400 kv. or higher.

In plotting the absorption curves shown in Figures 2, 3 and 4, the following distances were employed:

For 210 kv. (peak):

Tube to first diaphragm (and first filter)	40 cm.
Tube to second diaphragm and additional filter	70 cm.
Filters to ionization chamber	80 cm.

For 400 kv. (peak):

Tube to first diaphragm and filter, approximately	50 cm.
Tube to second diaphragm and additional filter	80 cm.
Filters to ionization chamber	90 cm.

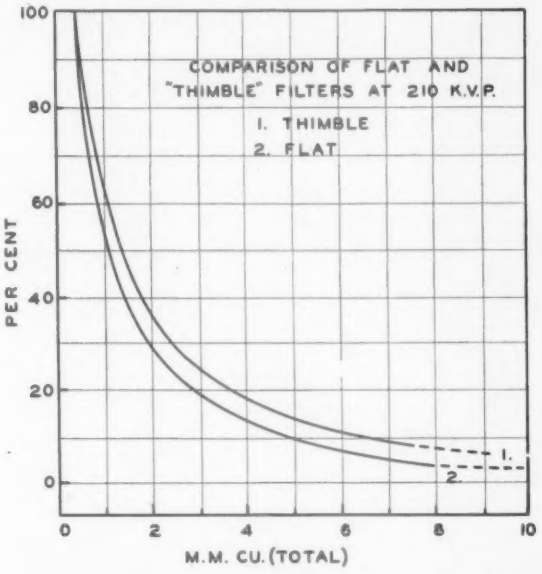

Fig. 3. Curve showing relation of flat to "thimble" filters at 210 kv. (peak).

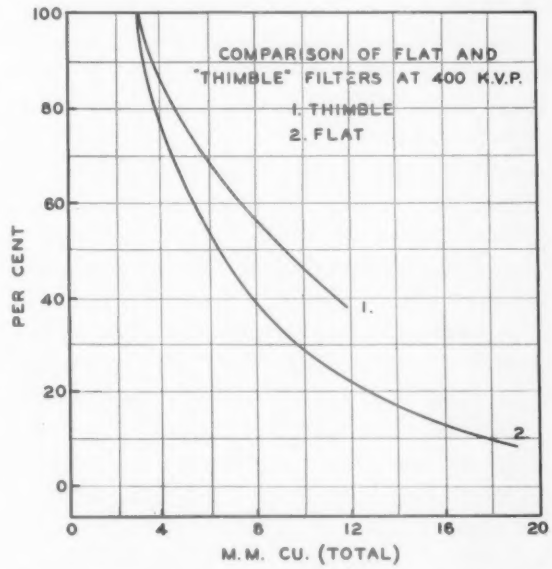

Fig. 4. Curve showing relation of flat to "thimble" filters at 400 kv. (peak).

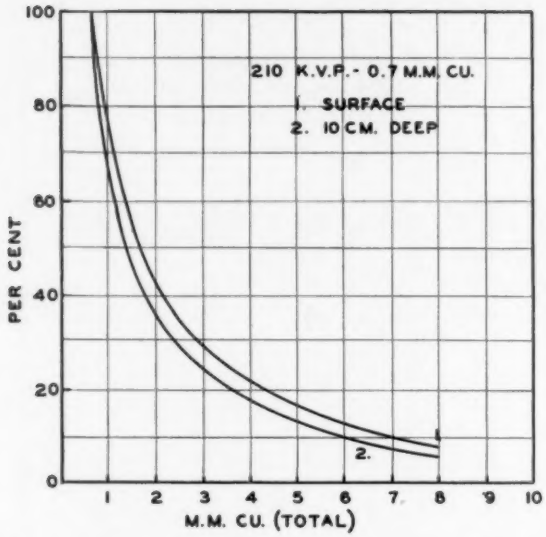

FIG. 5. Curve showing relative amounts of 210 kv. (peak) radiation absorbed by copper at different depths in the phantom.

The second diaphragm in both cases was 2 inches square and constructed from ½ inch lead. The ionization measurements were all made with a Glasser-Seitz type Victoreen condenser r-meter.

Twelve copper "thimble" type filters were used, each having a thickness of 0.58 mm. These filters were made by wrapping sheet copper around wooden dowels and "sweating" the lap joints, which were about 1 mm. wide. When in use, these soldered portions were carefully kept in a plane perpendicular to the rays. These filters are shown in Figure 1.

The 400 kv. (peak) ionization measurements were plotted on semi-logarithmic coordinate paper and the size of the diaphragms and the distances were varied until the slope of the straight portion of the curve was greatest. Distances greater than 90 cm. were not practical because of the portal-floor distance. Using the portion of this curve between 20 and 30 mm. of copper gives an absorption coefficient of 0.136 as compared with a value of 0.137 for 400 kv. constant potential, as given by Folsom.[2]

After taking the flat filter absorption data, the flat filters were removed and the "thimble" filters were placed successively over the ionization chamber without making any changes in the diaphragm system or the distances. A comparison of the flat and "thimble" chambers for 210 kv. (peak) is given in Figure 3 and for 400 kv. (peak) in Figure 4. As expected, the "thimble" filter curves come above those of the flat filters, due to the "wall effect" or scattering from the sides of the "thimbles." It can be seen very clearly why the "thimble" filter curves could not be used to define the quality of the rays. In this case, they are used merely to compare two radiations, *not to define them.*

"Thimble" filter absorption curves were made on the surface and at a depth of 10 cm. in the wax phantom. For 210 kv. (peak) an initial filtration of 0.7 mm. was used. This is the value used clinically and is composed of the 0.2 mm. inherent filtration in the tube plus a 0.5 mm. external filter. The results are shown in Figure 5 and are in fair agreement with the results obtained by Quimby and McNattin, the predicted softening being present to reduce the half-value layer from approximately 1 mm. at the surface to 0.7 mm. at a depth of 10 cm.

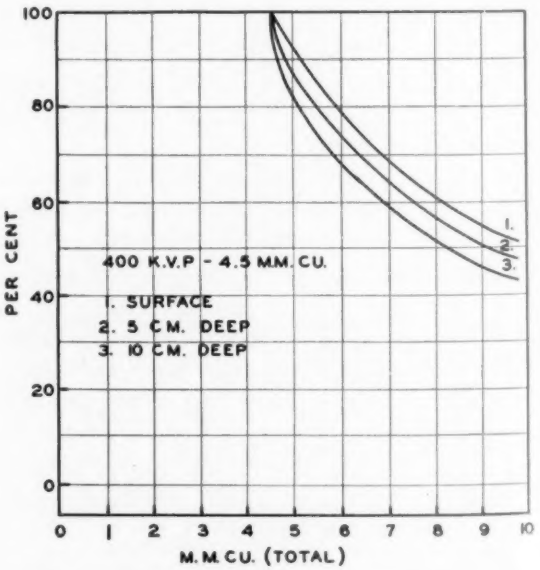

FIG. 6. Curve showing relative amounts of 400 kv. (peak) radiation absorbed by copper at different depths in the phantom.

At 400 kv. (peak) the filter employed was 4.5 mm. of copper which is the point where the semi-logarithmic absorption curve becomes practically a straight line, and is the filter used for treatment. Curves were made for the surface and for depths of 5 and 10 cm. in the wax. These curves are shown in Figure 6. The scattered radiation reduces the half-value layer from 5.6 mm. of copper at the surface to 4.5 mm. at a depth of 5 cm. and 3.8 mm. at 10 cm.

For lack of a better method of describing it, the half-value layer in copper has been used in the preceding paragraphs to compare the quality at a depth in the phantom with that on the surface. A study of the complete curves as shown in Figures 5 and 6, especially the upper portions, which are most affected by the very soft rays, gives a much truer idea of the increase in the softer components. The rapid dropping off of the upper portion of the curve for a depth of 10 cm. at 400 kv. (peak) indicates the presence of a large amount of soft radiation. If the thickness of copper required to reduce the radiation 10 or 20 per cent is noted and compared for 210 and 400 kv. (peak), the two types of radiation are seen to be more nearly similar at a depth of 10 cm. It is probably this soft radiation which is absorbed in the tissues and which produces the biological effects.

DISCUSSION

This investigation was undertaken because it was felt that a better knowledge of the quality of radiations used for therapy is needed. There is an increasing tendency to use higher voltage because of the corresponding increase in the depth dose. This increase in the percentage of the surface radiation which is present at any given depth can be proved by sound physical theory and experiments. However, Henshaw and Francis[3,4] have shown that with certain biological test objects the ratio between the ionization and the biological effects changes with a change in quality. They found further, that for gamma rays, when the surface ratio was 1:1:1, the ratio at a depth of 10 cm. became 13:19:66. This drastic change in relative radiosensitivity was apparently due entirely to the change in quality of the radiation in passing through the intervening tissue. Also, it can be seen that there was a complete reversal in the relative radiosensitivity caused by the change in the quality of the incident radiation from 200 kv. (peak) to gamma rays.

It was with the hope of obtaining a clearer idea of the mechanism causing the effects pointed out above that the present work was undertaken. No definite conclusions can be drawn from the work described herein, but it is felt that the data taken contribute materially to the knowledge of the quality of the radiation present at different depths in tissue. Since this quality has been shown to be an important factor in controlling the biological reactions, these data should be useful to future investigators attempting to discover the mechanism causing such reactions.

SUMMARY

1. Copper absorption curves made with "thimble" filters were compared with flat filters for 210 and 400 kv. (peak) roentgen radiation.

2. Copper absorption curves with "thimble" filters were made on the surface and at a depth of 5 and 10 cm. in a paraffin phantom.

3. From these absorption curves, it could be seen that roentgen rays at 210 and 400 kv. (peak) become softer after passing through paraffin (which has approximately the same effect as tissue). At a depth of 10 cm. it was shown that the 400 kv. (peak) rays contained a great deal of very soft radiation, and if compared with 210 kv. (peak) radiation, by noting the percentage passing through 0.10 mm. or less of copper, these radiations appeared more nearly similar. Although the 400 kv. (peak) radiation had softened considerably, it was still very much more penetrating than the corresponding 210 kv. (peak) radiation.

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A METHOD OF SIMPLIFIED DEPTH DOSAGE CALCULATION FOR CLINICAL PURPOSES

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THE need for determining the skin and depth dose in clinical practice was realized at an early stage in the development of roentgen therapy. It led to the adoption of universally recognized means of defining the physical data involved in actual treatment: the international roentgen providing the unit of roentgen-ray quantity and the now generally accepted half-value layer method allowing the quality of the radiation to be defined with reasonable accuracy. The introduction of clinical dosimeters in their various forms provided the radiologists with the tools for measuring and checking the physical factors involved in their work. Publications on clinical work, which contained the physical data of the radiation used could therefore be expected to prove useful as a basis for systematic research into radiotherapeutic methods. However, a survey of the literature shows that the usefulness of the published material is impaired by the fact that widely different methods have been adopted by different radiologists for arriving at their published skin and depth dose figures.

The use of different methods for calculating and measuring the skin and depth dose leads of necessity to divergent results and conclusions, for these figures are based either on calculations using Planck's constant, or on direct experimental observation, with one of the commercial dosimeters. The latter method is still connected with fundamental difficulties:[1] shape, size, and material of the ionization chamber used are of considerable influence on the results of the measurements. If clinical measurements are not made during treatment but on a phantom, the phantom material as well as the phantom's shape and size and the methods of defining the portal area are further potential sources of error.[2,8]

In view of the difficulties connected with *direct* clinical skin and depth dose measurements, a *calculation* of these figures, based on measurements of a more reliable type, will normally yield a higher degree of accuracy. The necessary clinical measurements can be reduced, in this case, to defining the intensity in free air (without backscatter) and the half-value layer of the radiation actually used for treatment. For these measurements a sufficient degree of accuracy can be obtained by using clinical dosimeters, thus providing a reliable foundation for the calculations. However, even these calculations sometimes prove unsatisfactory, notwithstanding their sound basic measurements, owing to the fact that the calculations are often carried out with the help of certain tables and graphs which have since been superseded by more exact and reliable material. The reason for this survival of the older data may be attributed to their convenience: their way of presenting the material apparently makes them more practicable in clinical practice than some of the more recent publications.*

Methods of calculating the skin and depth dose—using the latest available material on the relation between the various physical factors involved in roentgen therapy and combining it with the utmost simplicity in their application—seem therefore desirable.

Such methods are easily arrived at for the determination of skin dosage. The best data on this problem[8] can easily be put in the form of graphs from which the per-

* A discussion of the still existing discrepancies between the results of different investigators of the skin and depth dose question is outside the scope of this paper. Quimby, Marinelli and Farrow in their "Study of back-scatter"[8] and Packard's paper on "Calculation of percentage depth doses"[3] quote and compare the more important results of other workers and discuss this question rather extensively. These papers and references 2, 4, 5, 6 and 7 provide a bibliography which covers most of the subject.

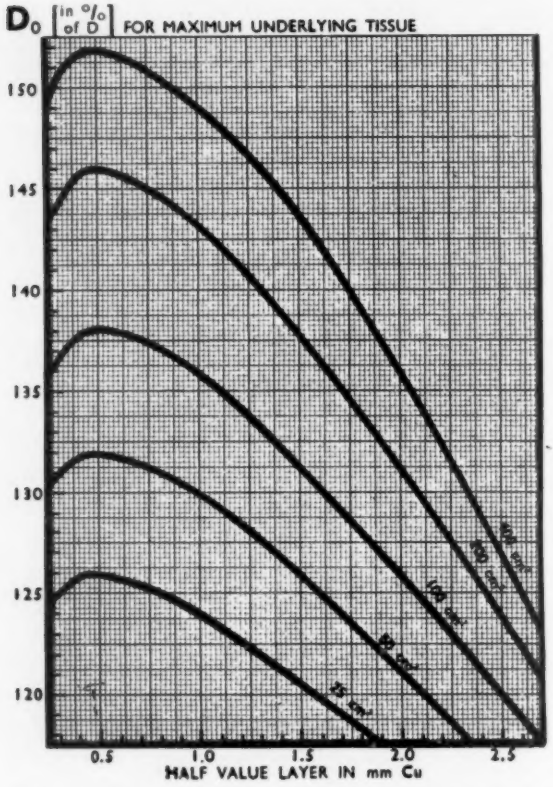

FIG. 1*a*. From the tables referred to in reference 8 graphs can be plotted which allow the skin dose to be read off immediately as a percentage of the incident radiation for a continuous range of quality of roentgen radiation and a selection of portal sizes. In order to show the dependence of the backscatter on the quality of the radiation and the size of the portal area the above graphs are drawn for the range 0.3 mm. to 2.5 mm. Cu half-value layer and portal areas of 25, 50, 100, 200 and 400 cm.²

centage backscatter or alternatively the skin dose as a percentage of the dose measured in free air can be read off immediately for a wide variety of treatment conditions. The simple principle is shown and explained in the graphs in Figures 1*a* and 1*b*. When both the radiation output in free air at the same focal distance and the half-value layer are known, one single multiplication gives the skin dose in tissue roentgens.

A method of similar simplicity for the determination of the depth dose does not present itself so readily on account of the many factors which are interconnected in this question. Packard's paper[3] provides a very ingenious method of graphical calculation. Its application in clinical practice is, however, impaired by the fact that each calculation necessitates—as pointed out by Packard—the following steps:

(1) The percentage depth dose for a given quality of radiation at 10 cm. depth with 40 cm. focal skin distance and 50 cm.² portal area has to be derived from a graph.

(2) The result of the first operation has to be amended from a nomogram for the wanted focal skin distance.

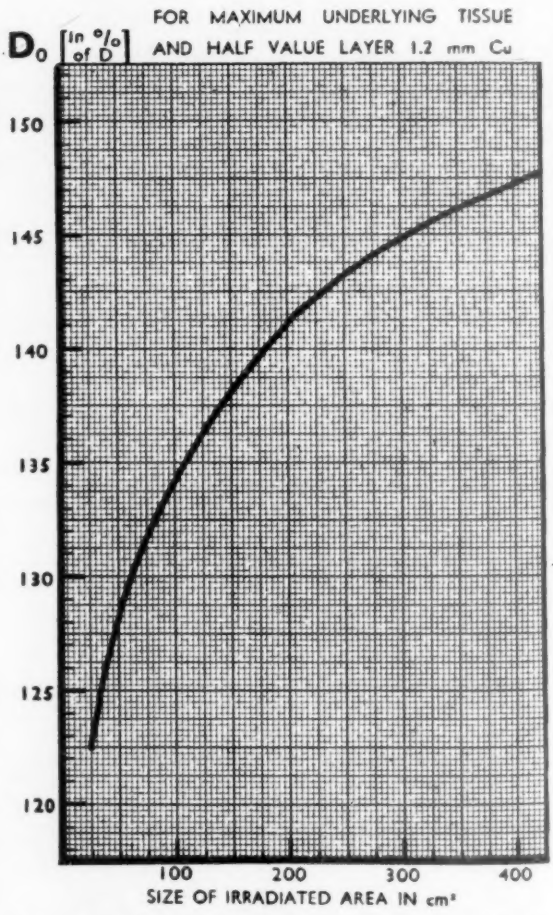

FIG. 1*b*. If the percentage backscatter or the skin dose is to be determined for a continuous range of portal sizes and a given half-value layer a graph of the above type will be found useful. For those half-value layer values which are not included in the tables referred to in reference 8 the values can be arrived at from an auxiliary graph of the type shown in Figure 1*a*.

(3) The result of the second operation has to be amended from another nomogram for the wanted size of portal area.

(4) The result of the third operation has to be amended from another nomogram for the wanted depth.

(5) and (6) The result of the fourth operation provides the depth dose as a percentage of the skin dose. In order to arrive at the actual dose in tissue roentgens it is now necessary to determine the skin dose (e. g. by the method outlined in Figures 1*a* and 1*b*, involving two more operations: the determination of the percentage backscatter from the graph or the original tables and the multiplication).

(7) A further multiplication of the results of (4) and (6) gives the depth dose in tissue roentgens as the final result.

It will be shown that it is possible to replace this procedure for a range covering the main part of the usual deep therapy treatment conditions by a method that entirely eliminates the fifth and sixth operations and replaces the first, second and third operation by the reading of one single graph.

This simplified method is based on (a) the elimination of the skin dose value from the calculations and (b) on the fact that beyond 0.5 mm. Cu half-value layer, with increasing half-value layer a decrease in backscatter (Fig. 1*a*) occurs simultaneously with an increase in percentage depth dose (Fig. 2).

Customarily the skin dose* is expressed as the ratio D_0/D while the depth dose is

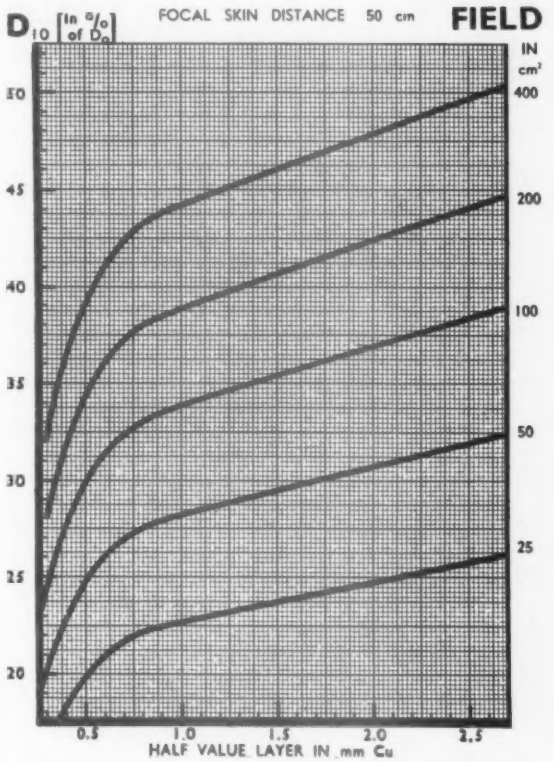

FIG. 2. In order to show the dependence of the 10 cm. depth dose on the quality of the radiation and the size of the portal area the above graphs are plotted for the same range of radiation quality and portal areas as those shown in Figure 1*a*.

expressed in terms of the skin dose as the ratio D_{10}/D_0. A multiplication of these ratios for corresponding values results in an expression D_{10}/D, defining the depth dose in terms of the incident radiation D and eliminating the skin dose value D_0.

For a wide range of qualities these values have been determined from the data given by Packard[3] and Quimby, Marinelli and Farrow,[8] covering the half-value layers between 0.3 mm. and 2.6 mm. Cu, the focal skin distances between 30 cm. and 120 cm. and the portal areas between 25 cm.² and 400 cm.² Some of the results are given in Figures 3, 4, 5, 6, 7 and 8. Values corresponding to any focal skin distance greater than 80 cm. are not shown on account of their rather limited practical value.

It will be seen from these graphs that for all investigated focal skin distances and portal areas the depth dose D_{10} expressed

* The following abbreviations are used:

D_{10}—for the depth dose in tissue roentgens, measured at 10 cm. depth in the center of the beam (similarly e.g. D_7 at 7 cm. depth, etc.).

D_0—for the skin dose in tissue roentgens, measured at the center of the beam with the measuring chamber half buried in the tissue, i.e. with its axis in the plane of the skin.

D—for the dose in roentgens, measured at the center of the beam in free air (without backscatter) at the same focal distance as D_0.

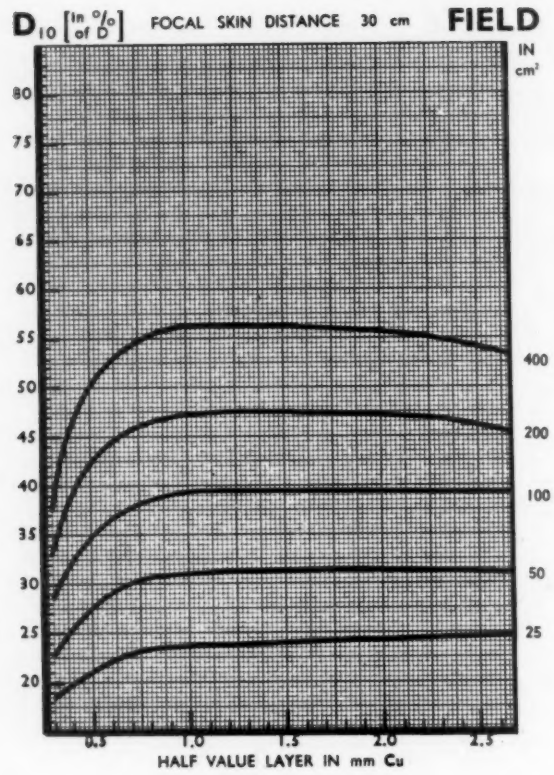

FIG. 3

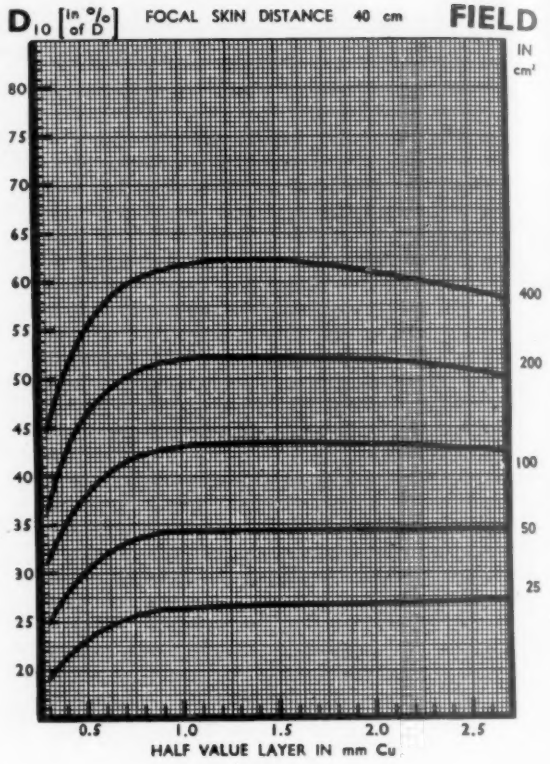

FIG. 4

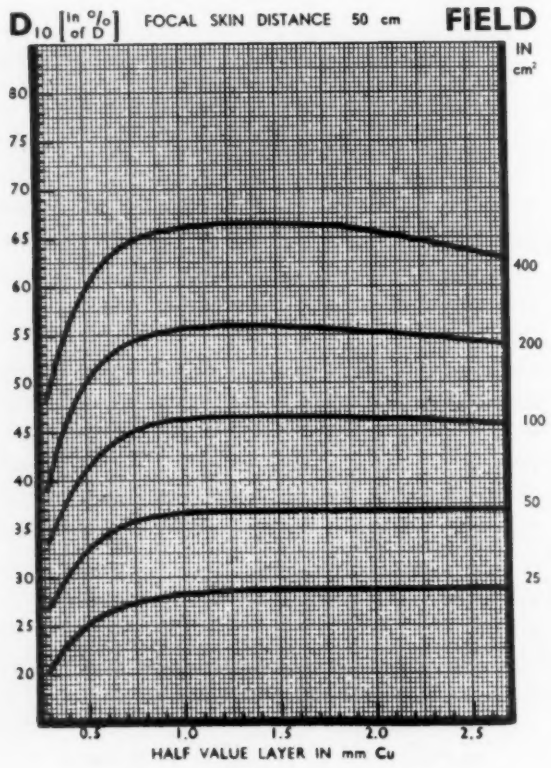

FIG. 5

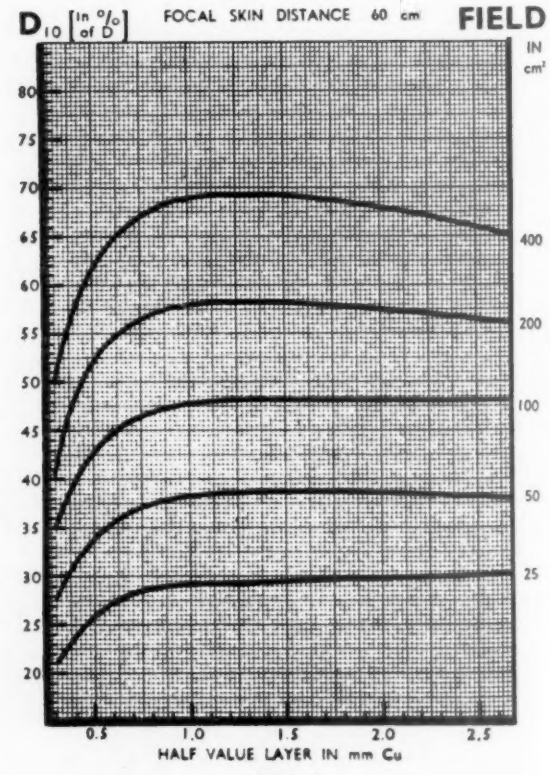

FIG. 6

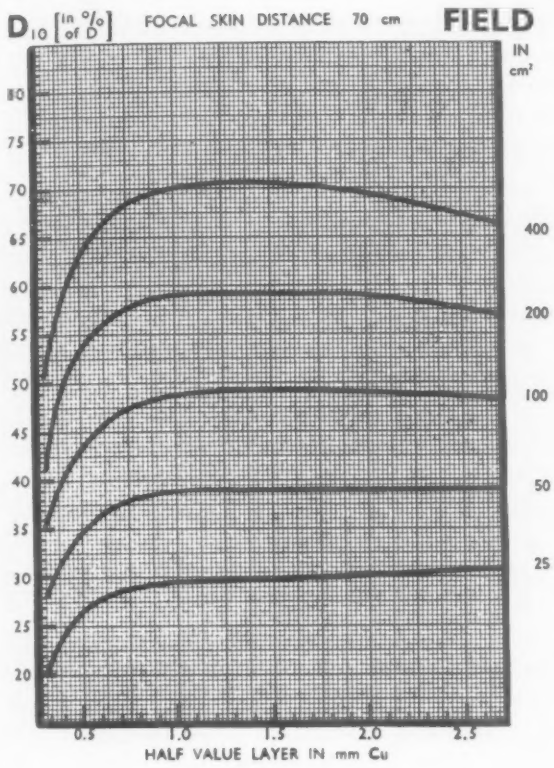

FIG. 7

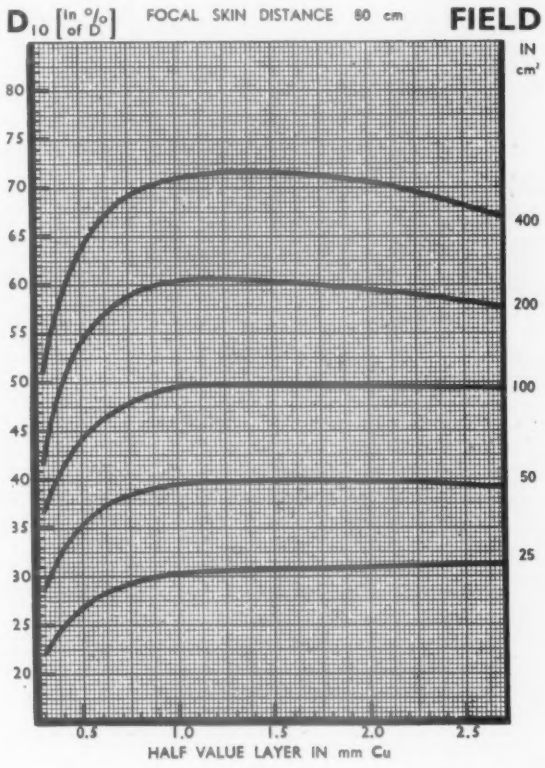

FIG. 8

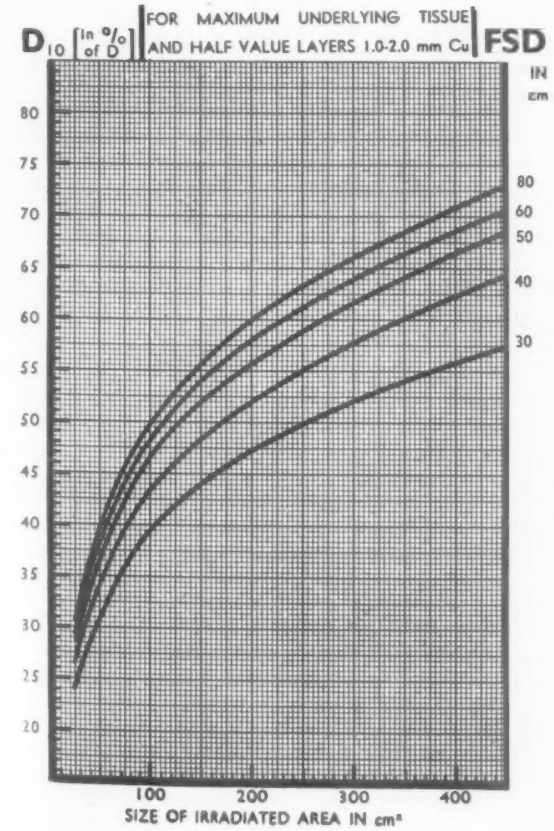

FIG. 9

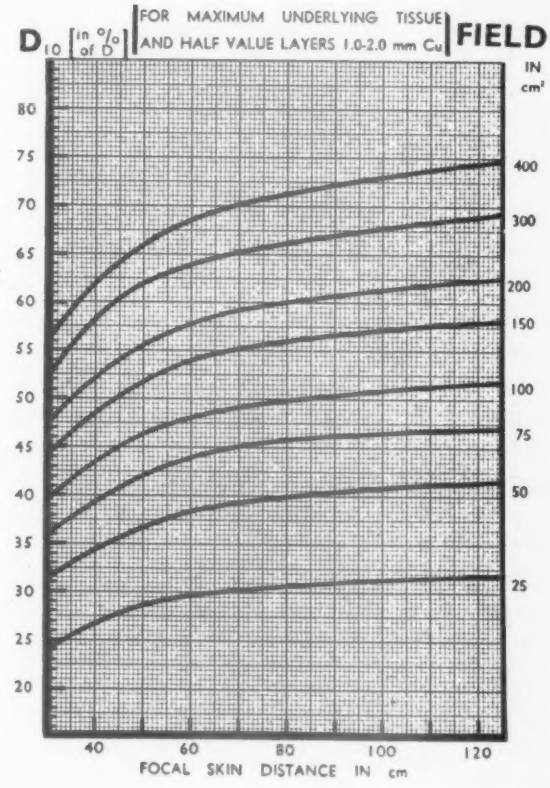

FIG. 10

as a percentage of the incident radiation D has practically the same value for any half-value layer between about 1.0 mm. and 2.0 mm Cu. This means that within this range of radiation quality the *increase* in depth dose caused by increased half-value layer is compensated by the *decrease* in backscatter.

It is therefore possible to plot the depth dose D_{10} as percentage of the incident radiation D for all radiation qualities between the half-value layer of 1.0 mm. and 2.0 mm. Cu so that this value can be read off immediately for any focal skin distance between 30 cm. and 120 cm. and for all sizes of portal areas between 25 cm.^{2} and 400 cm.^{2} This plotting can be done either in the form of Figure 9 or 10. The choice is is a matter of personal preference; both graphs give the same data and serve the same purpose. They differ only in the method of presentation because Figure 10 gives a continuous focal skin distance range and a selection of portal sizes, while Figure 9 covers a continuous range of portal sizes and a selection of focal skin distances. D_{10} values for the quality range from 0.3 mm. to 1.0 mm. and and from 2.0 mm. to 2.6 mm. Cu half-value layer can be arrived at for the focal skin distance range from 30 to 80 cm., using the data given in Figures 3 to 8. This will generally require an interpolation or the drawing of an auxiliary graph and will therefore not be as simple and satisfactory as the determination of values within the range 1.0 mm. to 2.0 mm. Cu half-value layer.

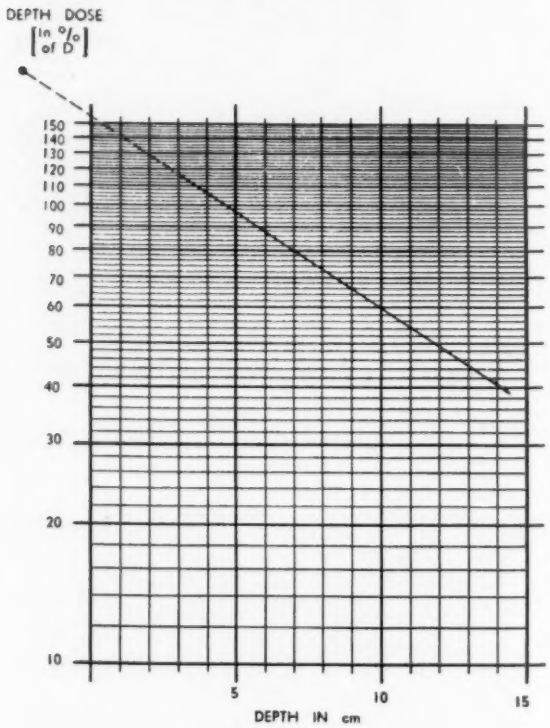

FIG. 11

If a dose other than at the 10 cm. depth is required the nomogram (Fig. 11) provides the possibility of finding the corresponding value by placing a straight edge between the known D_{10} value on the 10 cm. line and the focus in the left upper corner. The principle used by Packard[3] has been applied and therefore the same limitations apply for this nomogram as those pointed out by him. The most important of these limitations is the lack of accuracy for the first 3 cm. under the skin. For any depth greater than 3 cm. the accuracy obtainable by this method appears to be sufficient for clinical purposes and is of about the same order as that of the determination of the tumor depth.

The following example shows how the method outlined above is to be applied:

Suppose the dosage rate in tissue roentgens at 8 cm. depth is required for the following treatment conditions: 80 cm. focal skin distance; 200 cm.^{2} irradiated field; 1.6 mm. Cu half-value layer; dosage rate in free air at the same focal distance 20 r/min. A glance at the graph in either Figure 9 or 10 shows that D_{10} under these conditions is 60 per cent of D. If we now connect the point 60 on the 10 cm. ordinate of the nomogram (Fig. 11) with the focus by a straight line we find that the intersection with the 8 cm. ordinate corresponds to 73 per cent of D. The dosage rate at 8 cm. depth with the above treatment conditions is therefore 73 per cent of 20 r/min, or 14.6 r/min. The same procedure applies of course to

any other size of field or focal skin distance covered by the graphs as long as the half-value layer lies between about 1.0 mm. and 2.0 mm. Cu.

SUMMARY

A method of simplified depth dosage calculation for clinical purposes is presented, based on the fact that the dose at 10 cm. depth, expressed as a percentage of the incident radiation is practically constant for the same focal skin distance and size of field at any half-value layer between about 1.0 mm. and 2.0 mm. Cu. Graphs calculated on the basis of the data published by Packard[3] and Quimby, Marinelli and Farrow[8] are given which allow the value of the dose at 10 cm. depth to be read off immediately as a percentage of the incident radiation for any focal skin distance between 30 cm. and 120 cm. and for all sizes of portal areas between 25 cm.^{2} and 400 cm.^{2} Packard's method is applied to a nomogram allowing the determination of the depth dose as a percentage of the incident radiation at any other depth than 10 cm. Graphs are also given enabling depth dose values to be derived within the quality range from 0.3 mm. to 1.0 mm. and 2.0 mm. to 2.6 mm. Cu half-value layer. The view is expressed that a higher degree of accuracy can be obtained by calculating the skin and depth doses from reliable data than is normally achieved by attempting to actually measure these values in clinical practice either directly on the patient or with the help of phantoms.

Thanks are due to the New Zealand Branch of the British Empire Cancer Campaign Society and the Travis Trust for enabling this publication and to Professor F. W. G. White, Ph.D., K. R. Popper, Ph.D., and Mr. C. Ellyett, M.Sc., for their helpful suggestions in discussions of the subject.

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EDITORIALS

IRRADIATION AND THE ESTROGENIC THEORY OF MAMMARY CARCINOMA

THE surgical treatment of mammary carcinoma was based from the earliest days on the principle of its unifocal nature. It was assumed that when no metastases had taken place and the primary focus was completely removed, a permanent cure could be expected in most instances. The only two prerequisites for success were that the carcinoma be within the borderline of operability and that the operation itself be as radical as possible.

Later, when the results failed to come up to expectation, radiation therapy was added to the treatment armamentarium. The aim was to destroy the microscopic tumor cells which, on the basis of past experience, were thought to have invaded the surrounding structures, especially the lymphatics around a carcinoma focus, but which could not be seen with the naked eye at the time of operation. This innovation has given rise to prolonged and often animated discussions concerning the relative value of the two methods. After nearly two decades of extensive clinical observations and elaborate comparative statistical surveys of the five year results the problem is still somewhat confused. It is admitted, although by no means generally, that some benefit may be derived from the association of irradiation with surgical procedures when the mammary carcinoma has spread to the regional lymph nodes, or that radiation therapy may constitute the sole method of approach when the disease is far advanced. But, in a carcinoma localized to the primary focus, it is contended that radical surgery alone will bring about a cure in at least 80 per cent of the cases and that nothing more could be gained from supplemental radiation therapy.

Yet more recent statistical studies comprising systematic follow-up surveys over ten to fifteen years seem to indicate that a local recurrence or metastasis may occur even in the earliest forms of mammary carcinoma at a considerably later time than the accepted five year period. In the Radiologic Department of Harper Hospital it was found,[1] for example, that one-half of the patients who were apparently cured of mammary carcinoma at the end of five years died up to the fifteen year period. If this number was converted into the basic 100 per cent, 60 per cent represented death from carcinoma and only 40 per cent from other causes, a fact which suggests that perhaps if all patients had lived long enough, carcinoma might have accounted for death even more often. In many instances, a single recurrence developed first; then after apparently successful irradiation, new recurrences kept coming, each a little more malignant than its predecessor, until finally systemic dissemination had put an end to the local situation. In others, multifocal recurrences formed the precursors of rapid generalization of the carcinoma from the beginning. In still others, widespread distant metastases were noted without evidence of any local manifestation of the disease.

All of these observations suggest that mammary carcinoma does not always originate from a single focus and that, when it does, its removal by surgery or destruction by irradiation cannot be expected to lead to a complete eradication of the disease

[1] Evans, W. A., and Leucutia, T. Deep roentgen-ray therapy of mammary carcinoma. III. Fifteen year results in a formerly published group and a statistical analysis of 1,200 cases treated between 1922 and 1937. Am. J. Roentgenol. & Rad. Therapy, 1939, *42*, 866–882.

unless the underlying cause has been removed at the same time. Such a conception is in accord with the theory of the estrogenic causation of mammary carcinoma.

Indeed, multifocal carcinoma of the breast often occurs in animals, especially mice, either spontaneously or induced artificially by estrogens. On the other hand, a single carcinoma focus of the breast may develop when injected ovarian hormone has been carried by the blood stream to all portions of the mammary gland. It has been demonstrated experimentally that the hormonal effect elicits epithelial stimulation which is either diffuse or localized to one portion of the breast. A good example of the former is the formation by budding of new acini in the breast of male mice and of the latter, the papillomatous growth. From this first stage of hyperplasia successive stages then gradually lead to malignant neoplasia. In most cases the process is slow and reactions of various stages may be encountered at the same time, until at one more advanced point the change culminates in carcinoma. In others, as for example localized papillomata, the malignant transformation may occur quite suddenly. In either instance the end result is a unifocal carcinoma. But if the pathologic tissue reactions become very intensive, multicentric foci of the carcinoma may appear, especially since the mammary system in mice is considerably more extensive relative to the rest of the body than in the human.

Recently, Muir,[2] on the basis of a large number of cases from the Pathology Department of the Glasgow Western Infirmary, studied in extenso the tissue changes during the evolution of mammary carcinoma of women in relation to the estrogenic etiology. He paid considerable attention to the phases of structural variations just preceding the onset of the carcinoma whenever the development of malignancy could be definitely traced. Assuming that the malignant neoplasia arises either in the ducts or the acini before it actually infiltrates the neighboring tissues, he divided the subject into two main headings: (1) intraduct carcinoma, which may develop within the ducts and cysts as a sequel to papilloma or apart from this condition; and (2) intra-acinous carcinoma which is observed in the acini although its evolution is often very difficult to follow. Some other cases of doubtful evolution were also considered.

In all these instances, Muir found no evidence of factors supporting the theory of dual causation, according to which the diffusely acting hormone leads to hyperplasia but the carcinoma is the result of the additional action of a virus. On the contrary, all his observations pointed to the fundamental fact that malignancy is the end result of the growth-stimulating hormonal agent.

The adherents of the dual causation theory lay great emphasis on the unifocal origin of the carcinoma. It is assumed that the virus settles at one particular point of the hyperplastic breast and that thus cancer starts at one single focus, in small groups of cells or even in a single cell. But, according to Muir, this unicentricity may simply be due to the fact that the most advanced stage of the hyperplastic process occurs frequently at one point. Such a view is supported also by the inequality of response which is observed throughout the various parts of the mammary gland, and, for that matter, in any other organ reacting to the estrogen. Some ducts may show, for example, cystic or hyperplastic change, while others may appear entirely normal. Likewise, some acini may undergo abnormal growth, while others in the same group may not be affected at all. The unifocal outbreak of carcinoma, in such a terrain, would therefore only mean that the reactive changes had reached their climax at one particular point sooner than at others. It could not, in itself, be taken as evidence of the additional action of a virus and still less as disproval of its dependence on an estrogenic carcinogen circulating in the

[2] Muir, Robert. Evolution of carcinoma of the mamma. *J. Path. & Bacteriol.*, 1941, *52*, 155–172.

blood stream. If this interpretation is accepted, one may expect, as in mice, the occasional occurrence of mammary carcinoma, especially when the hyperplasia is greatly accelerated by the excess of hormone, in more than one center at the same time. There may arise independent foci in ducts and acini, or in both. Moreover, if the original focus or foci are removed or destroyed and the estrogenic effect continues unabated, the successive epithelial stimuli may culminate in carcinoma at some other point or points. Such a situation may conceivably be likened to that observed clinically when, as already stated, recurrence or a series of recurrences develops over a long period of time even in the localized forms of mammary carcinoma despite most radical surgery and most intensive irradiation.

Another point stressed by Muir is that the malignant change often affects the cells of a given area of the mamma in a diffuse manner, so that the carcinomatous invasion is more regional than focal. This was observed in all three situations studied—papillomata, ducts apart from these, and acini. It was thought that the malignant neoplasia in such cases represents the final stage of an especially active proliferative process, induced by a continuous excess of the growth-stimulating estrogen.

The implications of all these observations can obviously not remain without influence on the general clinical considerations of mammary carcinoma.

In the first place, by harmonizing the findings of a systematic year by year follow-up over a long period of time with the estrogenic theory of causation, one will find it difficult to talk about a "cure" of cancer of the breast even after ten or fifteen years, or perhaps at any time. This fact, based on other considerations, was vividly exemplified by McFarland[3] in the Caldwell Lecture of 1938. Some other term, as for example, "survival" would be more appropriate for the designation of the periodical late results.

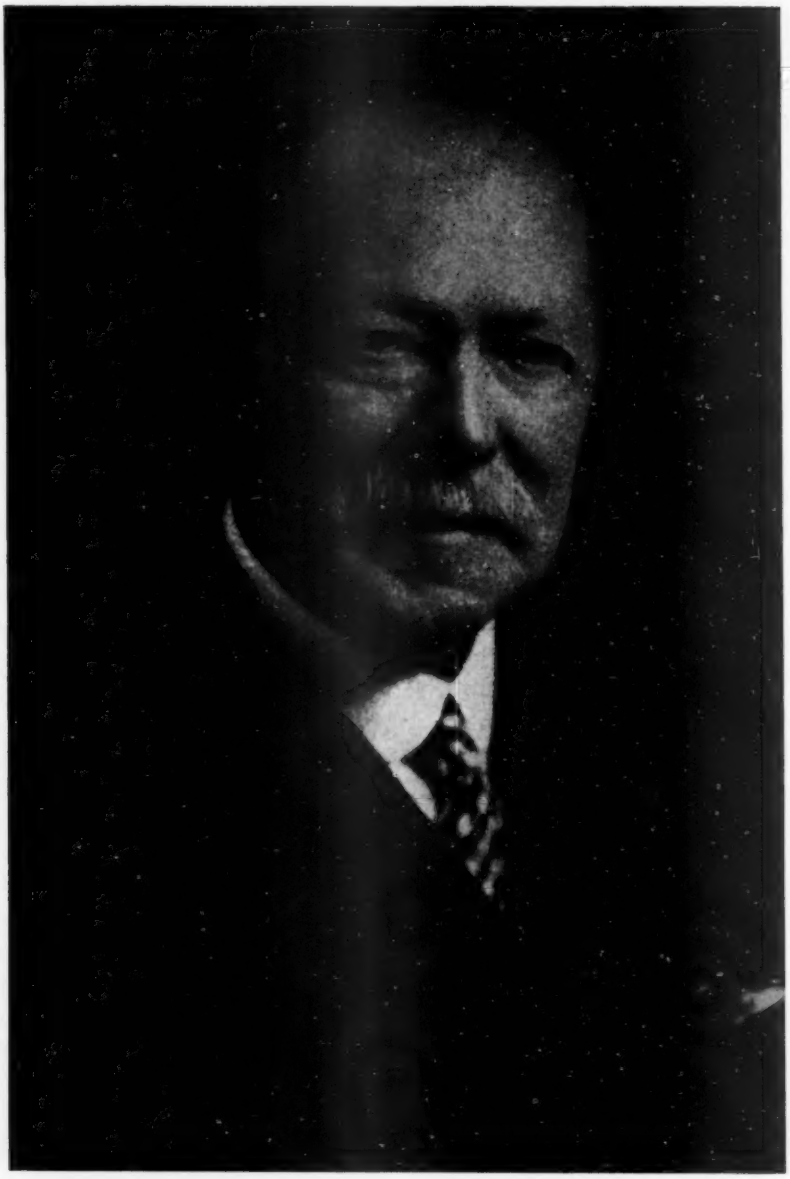
Secondly, in considering the treatment of mammary carcinoma, emphasis should be placed on a thorough local and regional irradiation, either in association with surgery when the lesion is operable, or alone, when the borderline of operability has been passed. But above all, repeated check-up examinations are necessary after the completion of the initial treatment. These examinations are carried out at intervals of two months during the first two years, and at gradually spaced intervals thereafter, for an indefinite period. By thus proceeding a new manifestation of the carcinoma is discovered early and in consequence re-treated under more favorable conditions. The value of the irradiation in all these instances cannot be overestimated.

Thirdly, the question arises whether or not routine exovulation through destruction of the estrogen-producing source might not help to improve the late results over a long period of time. The experimental data and especially the clinical observations in this respect are still contradictory and therefore the subject must be left an open one.

All in all, it seems that the acceptance of the estrogenic theory of the causation of mammary carcinoma creates new clinical and radiotherapeutic problems which will acquire an increasing importance as time passes.

T. Leucutia

[3] McFarland, Joseph. Keeping in step with science. Caldwell Lecture, 1938. Am. J. Roentgenol. & Rad. Therapy, 1939, *42*, 161–172.



CHARLES THURSTAN HOLLAND
1863–1941

ON NOVEMBER 5, 1897, less than a year after the discovery of x-rays, a paper on the subject was read by Sylvanus Thompson at a meeting held in London to inaugurate the formation of the Röntgen Society, a Society which still exists incorporated with the British Institute of Radiology. Among those present at this meeting were a few medical men who decided to devote themselves to the application of the new discovery to the needs of medicine. Of this very small band Thurstan Holland was one, and within a few years he had become the most eminent exponent of this new branch of medicine in Great Britain. He was elected president of the Röntgen Society in 1904 and again in 1916. In his address on the latter occasion he wrote:

"It is twenty years since I took my first radiograph, twenty years brimful of interest, and of advances which in those days none of us could have even dreamed about, advances which may perhaps be illustrated by the fact that the first successful radiograph I saw taken [by Oliver Lodge in January, 1896] was that of a hand, and the exposure was 1¾ hours." He lived to see such exposures made as a routine in 1/10 second, even with portable apparatus. His professional life was a constant voyage of exploration, for he took nothing for granted, testing out every new technique and surveying every paper with a critical eye. No man was better fitted by natural gifts to be a pioneer or to enjoy to the full the thrills of scientific discovery.

In the rapid evolution of medical radiology and its applications to almost every branch of medicine and surgery, particularly in urinary roentgenology, Holland took a leading part. He was one of the first to demonstrate the presence of a stone in the kidney and to obtain the shadow of the kidney outline as a *sine qua non* of a satisfactory roentgenogram of the kidney region. His meticulously careful technique and expert knowledge of photography resulted in the production of roentgenograms that were far in advance of standard practice for many years. Moreover, he brought to the task of the interpretation of his results exceptional clinical experience that was coupled with logical and rapid judgment. Little wonder, therefore, that he made his mark not only as a pioneer but also as a leader.

Although he practiced in Liverpool, he nevertheless found time to keep in close touch with his colleagues in London, where he served on almost every radiological committee of importance. His commanding presence and outstanding personality were associated with exceptional shrewdness of judgment and a knack of getting down to essentials. His influence on committees was profound.

A typical reminiscence sometimes reveals the man. A meeting was arranged in about 1908 for the purpose of laying down a formula for a standard bismuth meal. After long discussion Holland got up and said that he was all in favor of a standard bismuth meal provided it was the one that he himself was using! It was said with a chuckle, everyone laughed, nothing was done; the time was not ripe for standardization.

Holland's contributions to the literature of medical radiology were numerous and covered a wide field. So early as 1898–1899 he wrote on the successful treatment of lupus and eczema by means of roentgen rays. Later he turned his attention to the diagnosis of chest conditions and those of the urinary tract. Working with his friend the late Sir Robert Jones, he made many valuable contributions to the study of diseases and abnormalities of bones. The Royal College of Surgeons acknowledged the value of this work by electing him as a fellow of the College. A list of about a hundred of his papers up to 1922 covers practically every field of medical radiology that had been explored up to that time.

There was no ambiguity in Holland's make-up and this was reflected in his papers and lectures. His directness and fearlessness were at times embarrassing in discussion, particularly when he criticized work that was not satisfactory. As a teacher his dogmatism, well justified by long experience, was much appreciated by his students, who learned to love as well as to respect this rather formidable personality. He was not one of those who suffer fools gladly, yet he was extraordinarily patient with students and earned a reputation for kindness and consideration. He took great pride in the careers of his students, which formed one of his major interests in the last years of his life.

During the War of 1914–1918 Holland served as a Major in the First Western General Hospital. His common-sense methods in the localization of foreign bodies were adopted by many roentgenologists.

He attained to all the honors that were possible in his branch of medicine and was

president of the Electro-therapeutic Section of the Royal Society of Medicine, of the Röntgen Society (twice), and of the British Institute of Radiology. He was an honorary fellow of the American College of Radiology and an honorary member of the American Roentgen Ray Society and of most of the continental radiological societies. It was always a disappointment to him that, being a very bad sailor, he felt unable to cross the ocean to repay the visits that so many Americans had paid to him. When he was elected President of the First International Congress of Radiology in 1925 he attained the highest honor that his colleagues could confer on him.

Outside his profession his hobbies were Alpine photography and mountaineering. During the last years of his life he lived in retirement; but he still took an active interest in radiology and, as *doyen* of the radiologists, he attended many of the public functions until ill-health supervened. With his passing on January 16, 1941, at the age of seventy-seven, radiology has lost a leader, the last of the pioneers, who did much to establish this branch of medicine on a sound basis.

A. E. BARCLAY

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

United States of America

American Roentgen Ray Society
Secretary, Dr. C. B. Peirce, Royal Victoria Hospital, Montreal, Canada. Annual Meeting: Cincinnati, Ohio, Sept. 23–26, 1941.

American College of Radiology
Secretary, Mac F. Cahal, 540 N. Michigan Ave., Chicago, Ill. Annual meeting: Hotel Statler, Cleveland, June 4, 1941.

Section on Radiology, American Medical Association
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting: Cleveland, Ohio, June 2–6, 1941.

Radiological Society of North America
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: San Francisco, Calif., Nov. 30–Dec. 5, 1941.

Radiological Section, Baltimore Medical Society
Secretary, Dr. Walter L. Kilby, Baltimore. Meets third Tuesday each month, September to May.

Section on Radiology, California Medical Association
Secretary, Dr. Wilbur Bailey, 2007 Wilshire Blvd., Los Angeles.

Radiological Section, Connecticut Medical Society
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets bi-monthly on second Thursday, at place selected by Secretary. Annual meeting in May.

Section on Radiology, Illinois State Medical Society
Secretary, Dr. H. W. Ackemann, 321 W. State St., Rockford, Ill.

Radiological Section, Los Angeles Co. Med. Soc.
Secretary, Dr. Wilbur Bailey, 2007 Wilshire Blvd., Los Angeles, Calif. Meets on second Wednesday of each month at County Society Building.

Radiological Section, Southern Medical Association
Secretary, Dr. Roy G. Giles, Temple, Texas.

Brooklyn Roentgen Ray Society
Secretary, Dr. L. J. Taormina, 1093 Gates Ave., Brooklyn, N. Y. Meets monthly on fourth Tuesday, October to April.

Buffalo Radiological Society
Secretary, Dr. Joseph S. Gian-Francheschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months.

Chicago Roentgen Society
Secretary, Dr. C. J. Challenger, 3117 Logan Blvd. Meets second Thursday of each month October to April inclusive at the Palmer House.

Cincinnati Radiological Society
Secretary, Dr. J. E. McCarthy, 707 Race St., Cincinnati, Ohio. Meets third Tuesday of each month, October to May, inclusive.

Cleveland Radiological Society
Secretary, J. O. Newton, 13921 Terrace Rd., East Cleveland. Meets at 6:30 P.M. at Midday Club on fourth Monday each month, October to April, inclusive.

Denver Radiological Club
Secretary, Dr. P. R. Weeks, 520 Republic Bldg., Denver, Colo. Meets third Friday of each month.

Detroit Roentgen Ray and Radium Society
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Medical Society Building.

Florida State Radiological Society
Secretary, Dr. J. N. Moore, 210 Professional Bldg., Ocala, Florida. Meetings in May and November.

Georgia Radiological Society
Secretary, Dr. R. C. Pendergrass, Prather Clinic Bldg., Americus, Ga. Meets in November and at annual meeting of Medical Association of Georgia in the spring.

Illinois Radiological Society
Secretary, Dr. Wm. DeHollander, St. John's Hospital, Springfield, Ill. Meets three times a year.

Indiana Roentgen Society
Secretary, Dr. C. C. Taylor, 23 E. Ohio St., Indianapolis, Ind. Meeting held the second Sunday in May annually.

Kentucky Radiological Society
Secretary, Dr. J. C. Bell, 402 Heyburn Bldg., Louisville. Meets annually in Louisville on third Sunday afternoon in April.

Long Island Radiological Society
Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:30 P.M.

Louisiana Radiological Society
Secretary, Dr. J. R. Anderson, 1130 Louisiana Ave., Shreveport. Meets annually during Louisiana State Medical Society meeting. Next meeting New Orleans, April, 1942.

Michigan Association of Roentgenologists
Secretary, Dr. J. E. Lofstrom, 1536 David Whitney Bldg., Detroit. Three meetings a year, Fall, Winter, Spring.

Milwaukee Roentgen Ray Society
Secretary, Dr. I. I. Cowan, Mt. Sinai Hospital, Milwaukee, Wis. Meets monthly on first Friday at University Club.

Minnesota Radiological Society
Secretary, Dr. J. P. Medelman, 572 Lowry Medical Arts Bldg., St. Paul.

Nebraska Radiological Society
Secretary, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Nebr. Meets third Wednesday of each month, at 6 P.M. at either Omaha or Lincoln.

New England Roentgen Ray Society
Secretary, Dr. A. O. Hampton, Massachusetts General Hospital, Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

Radiological Society of New Jersey
Secretary, Dr. W. J. Marquis, 198 Clinton Ave., Newark. Meets annually at time and place of State Medical Society. Mid-year meetings at place chosen by president.

New York Roentgen Society
Secretary, Dr. E. J. Ryan, St. Luke's Hospital, New York City. Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

North Carolina Roentgen Ray Society
Secretary, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

Central New York Roentgen Ray Society
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse. Three meetings a year. January, May, November.

Ohio Radiological Society
Secretary, Dr. J. E. McCarthy, 707 Race St., Cincinnati. Meets at time and place of annual meeting of Ohio State Medical Association.

Pacific Roentgen Society
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

Pennsylvania Radiological Society
Secretary, Dr. L. E. Wurster, 416 Pine St., Williamsport.

Philadelphia Roentgen Ray Society
Secretary, Dr. B. R. Young, Temple University Hospital. Meeting first Thursday of each month from October to May inclusive, at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

Pittsburgh Roentgen Society
Secretary, Dr. H. W. Jacox, 4800 Friendship Ave. Meets second Wednesday each month, 4:30 P.M., October to June, Pittsburgh Academy of Medicine.

Rochester Roentgen Ray Society, Rochester, N. Y.
Secretary, Dr. S. C. Davidson, 277 Alexander St. Meets on second Thursday from October to May, inclusive, 8 P.M., Rochester Academy of Medicine Building.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

ST. LOUIS SOCIETY OF RADIOLOGISTS
Secretary, Dr. W. K. Mueller, University Club Bldg. Meets fourth Wednesday of October, January, March and May, at a place designated by the president.

SAN FRANCISCO RADIOLOGICAL SOCIETY
Secretary, Dr. H. A. Hill, 450 Sutter St., San Francisco. Meets monthly on third Thursday at 7:45 P.M., first six months at Toland Hall, second at Lane Hall.

SOUTH CAROLINA X-RAY SOCIETY
Secretary, Dr. T. A. Pitts, Baptist Hospital, Columbia, S. C. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

TENNESSEE RADIOLOGICAL SOCIETY
Secretary, Dr. F. B. Bogart, 311 Medical Arts Bldg., Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

TEXAS RADIOLOGICAL SOCIETY
Secretary, Dr. L. W. Baird, Scott and White Hospital, Temple, Texas.

UNIVERSITY OF MICHIGAN DEPARTMENT OF ROENTGENOLOGY STAFF MEETING
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

UNIVERSITY OF WISCONSIN RADIOLOGICAL CONFERENCE
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets every Thursday from 4:00–5:00 P.M., Room 301, Service Memorial Institute.

VIRGINIA RADIOLOGICAL SOCIETY
Secretary, Dr. C. H. Peterson, 603 Medical Arts Bldg., Roanoke, Va. Meets annually in October.

WASHINGTON STATE RADIOLOGICAL SOCIETY
Secretary, Dr. K. J. Holtz, American Bank Bldg., Seattle. Meets fourth Monday of each month at the College Club, Seattle.

X-RAY STUDY CLUB OF SAN FRANCISCO
Secretary, Dr. J. M. Robinson, University of California Hospital. Meets monthly in evening on third Thursday.

CUBA

SOCIEDAD DE RADIOLOGÍA Y FISIOTERAPIA DE CUBA
President, Dr. J. Manuel Viamonte, Hospital Mercedes, Habana, Cuba. Meets monthly in Habana.

BRITISH EMPIRE

BRITISH INSTITUTE OF RADIOLOGY INCORPORATED WITH THE RÖNTGEN SOCIETY
Meets monthly on third Thursday from November to June inclusive, at 8:15 P.M., 32 Welbeck St., London.

SECTION OF RADIOLOGY OF THE ROYAL SOCIETY OF MEDICINE (CONFINED TO MEDICAL MEMBERS)
Meets on the third Friday of each month during the winter at 8:15 P.M. at the Royal Society of Medicine, 1, Wimpole St., London, W. 1.

FACULTY OF RADIOLOGISTS
Secretary, Dr. M. H. Jupe, 32 Welbeck St., London, W. 1, England.

SECTION OF RADIOLOGY AND MEDICAL ELECTRICITY, AUSTRALASIAN MEDICAL CONGRESS
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

RADIOLOGICAL SECTION OF THE VICTORIAN BRANCH OF THE BRITISH MEDICAL ASSOCIATION
Secretary, Dr. Keith Hallam, St. George's Hospital, K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to November inclusive.

CANADIAN ASSOCIATION OF RADIOLOGISTS
Secretary, Dr. A. C. Singleton, Medical Arts Bldg. Toronto, 5, Ontario.

SECTION OF RADIOLOGY, CANADIAN MEDICAL ASSOCIATION
Secretary, Dr. C. M. Jones, Inglis St., Ext., Halifax, N.S.

RADIOLOGICAL SECTION, NEW ZEALAND BRITISH MEDICAL ASSOCIATION
Secretary, Dr. Colin Anderson, Invercargill, New Zealand. Meets annually.

CONTINENTAL EUROPE

BELGIAN SOCIETY OF ROENTGENOLOGY
Secretary, Dr. J. Boine, Avenue des Alliés, 134, Louvain (Belgium). Meets monthly on second Sunday at d'Egmonds Palace, Brussels, except in the summertime.

SOCIEDAD ESPANOLA DE RADIOLOGIA Y ELECTROLOGIA
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7. Madrid, Spain. Meets monthly in Madrid.

SOCIÉTÉ DE RADIOLOGIE MÉDICALE DE FRANCE
Meets monthly on second Tuesday, except during months of August and September, 12 Rue de Saine, Paris.

SOCIÉTÉ SUISSE DE RADIOLOGIE (SCHWEIZERISCHE RÖNTGEN-GESELLSCHAFT)
Secretary for French language, Dr. A. Grosjean La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse, Biel. Meets annually in different cities.

SOCIÉTÉ FRANCAISE D'ELECTROTHÉRAPIE ET DE RADIOLOGIE MÉDICALE
Meets monthly on fourth Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

ASSOCIATION OF GERMAN ROENTGENOLOGISTS AND RADIOLOGISTS IN CZECHO-SLOVAKIA
Secretary, Dr. Walter Altschul, German University, Prague, II.52.

DEUTSCHE RÖNTGEN-GESELLSCHAFT (GESELLSCHAFT FÜR RÖNTGENKUNDE UND STRAHLENFORSCHUNG)
Meets annually in April, alternating one year in Berlin, one year in some other German city. Meets in addition every two years with the Gesellschaft deutscher Naturforscher und Aertze.
Permanent Secretary, Professor Dr. Haenisch, Klopstockstrasse 10, Hamburg, Germany.

SÜD- UND WESTDEUTSCHE RÖNTGENGESELLSCHAFT
Meets annually in different cities.

NORD- UND OSTDEUTSCHE RÖNTGENGESELLSCHAFT
Meets annually in different cities.

DUTCH SOCIETY OF ELECTROLOGY AND ROENTGENOLOGY
Holds two meetings a year in Amsterdam, one in the spring, and one in the fall.

SOCIETA ITALIANA RADIOLOGIA MEDICA
Secretary, M. Ponzio, University of Turin, Prof. Turin.

SOCIETATEA ROMANA DE RADIOLOGIE SI ELECTROLOGIE
Secretary, Dr. Oscar Meller, Str. Banul Mărăcine, 30, S. I., Bucuresti, Roumania. Meets second Monday in every month with the exception of July and August.

ALL-RUSSIAN ROENTGEN RAY ASSOCIATION, LENINGRAD, USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

LENINGRAD ROENTGEN RAY SOCIETY
Secretaries, Drs. S. G. Simonson and G. A. Gusterin. Meets monthly, first Monday at 8 o'clock State Institute of Roentgenology and Radiology, Leningrad.

MOSCOW ROENTGEN RAY SOCIETY
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly, first Monday, 8 P.M.

SCANDINAVIAN ROENTGEN SOCIETIES
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association. Each of the following societies, with exception of the Denmark Society, meets every second month except in the summertime.

SOCIETY OF MEDICAL RADIOLOGY IN SWEDEN
Meets in Stockholm.

SOCIETY OF MEDICAL RADIOLOGY IN NORWAY
Meets in Oslo.

SOCIETY OF MEDICAL RADIOLOGY IN DENMARK
Secretary, Dr. G. Biering, Copenhagen. Meets second Wednesday each month October to July in Copenhagen, at 8 o'clock in State Institute of Roentgenology.

SOCIETY OF MEDICAL RADIOLOGY IN FINLAND
Meets in Helsingfors.

VIENNA ROENTGEN SOCIETY
Meets first Wednesday of each month, at 6:30 P.M. at Zentral-Röntgen Institut des allgemeinen Krankenhauses Alserstrasse 4.

ORIENT

JAPAN X-RAY ASSOCIATION
c/o Orthopedic Surgery, Tokyo Imperial University. Meets annually in April.

KINKI ROENTGEN-ABEND SOCIETY
Director, Dr. Prof. Taiga Saito, Ogawaoike Tyoto, Japan. Meets bi-monthly on third Sunday.

AMERICAN ROENTGEN RAY SOCIETY

The Forty-second Annual Meeting of the American Roentgen Ray Society is to be held at the Netherland Plaza, Cincinnati, Ohio, September 23–26, 1941. Plans are well in hand for the meeting. An interesting scientific program is being arranged by the President-Elect, Dr. William M. Doughty of Cincinnati, and he and his local committee are arranging the social events. Again the Instruction Courses which have proved so popular will be given, and again their arrangement is in charge of Dr. B. R. Kirklin whose past experience in this matter is assurance that the courses will be of great value to those who attend them.

Dr. Paul A. Bishop is Chairman of the Committee on Scientific Exhibits. Anyone having interesting material to exhibit should communicate with Dr. Bishop as soon as possible. Arrangements for the Commercial Exhibit are being completed rapidly and much interest has been shown by the various manufacturers, thus assuring a display even larger than previous ones.

The facilities of the Netherland Plaza are well adapted to the exacting requirements of such a meeting as that of the American Roentgen Ray Society; the personnel is most competent and the location of Cincinnati is a very convenient and central one. These are all facts conducive to a successful meeting.

The complete Instruction Courses and Scientific Program will be published in future issues of the JOURNAL. It is hoped that this preliminary announcement will serve to stimulate interest in the meeting and that plans may thus be made well in advance to attend this year's meeting of the American Roentgen Ray Society in Cincinnati.

DIRECTORY OF MEDICAL SPECIALISTS

A second edition of the Directory of Medical Specialists has been authorized by the Advisory Board for Medical Specialties, to be ready for distribution in February, 1942, with its contents complete to January first.

This Directory is the official publication of the Advisory Board, and will list the names of approximately 18,000 diplomates of the fifteen American Boards examining candidates for certification in the specialties. This is an increase of 4,000 over the first edition issued early in 1940.

The geographic grouping will give completely revised biographic data about each diplomate; there is an alphabetic index with addresses and specialty designations; and the plan of organization, officers, and examination requirements of each American Board are fully outlined in their various sections.

The biographic data of diplomates will not only be revised to date, but also will include much new information not found in the first edition. Details of formal training is one of these, and military appointments now held is another.

Only those who have been formally certified by one of the American Boards can have their names included, and all of these are included, there being no charge or obligation other than certification for such listings.

The official nature of this Directory makes it invaluable as a reference book. It may be used generally for the referring of patients to distant communities; for the information of Medical Society officers; for gaining detailed knowledge about qualified specialists throughout the United States and Canada; for the obtaining of detailed information about the American Boards; and for many other purposes.

The first edition had a wide distribution not only throughout the medical profession as well as medical and other public libraries, but also among insurance companies and business firms dealing with physicians. Nevertheless, it is not a commercial undertaking as the Directory contains no advertising material, is underwritten by the Advisory Board and actually received sub-

sidizing support so that it could be distributed as near to cost as possible.

Questionnaires for biographic data are now being mailed out with order forms. The Secretary of each Board urges that every diplomate return his questionnaire form as quickly as possible, and he is urged also to support this project of the American Board by his subscription to the Directory. A substantially reduced rate is offered for prepublication orders, as the size of the printing is based largely on advance subscriptions.

The publication is issued through the Columbia University Press of New York. The Secretary of each American Board serves on the Advisory Editorial Board, and Paul Titus, M.D., 1015 Highland Building, Pittsburgh, Pennsylvania, of the American Board of Obstetrics and Gynecology, is the Directing Editor.

AMERICAN BOARD OF RADIOLOGY

The number of applicants who wished to be examined in Cleveland, May 29, 30, 31 and June 1, was far greater than the Board could take care of at one examination. Arrangements are being made to schedule a second examination some time this fall at a convenient place. Inasmuch as there are already on file a very large number of applications for the coming examination, we would urge those who contemplate being examined this year to file their applications immediately.

B. R. KIRKLIN, *Secretary*

SAVE HOSPITAL RUBBER GOODS FOR NATIONAL DEFENSE

An appeal for hospitals to save and sell worn rubber goods of all kinds and grades in the interest of national defense has been initiated by the James M. Jackson Memorial Hospital, Miami, Florida. The Government needs all the rubber it can get and, in addition to buying it, a second method of procuring it is to conserve what is already in the United States. Nearly all hospitals, doctors and dentists in private practice, discard daily what to them is worthless rubber, but if saved and sold to scrap dealers it would find its way back to commercial reclamation plants, and hence would be available for national defense. Mr. Harvey S. Firestone, Jr., makes the following valuable suggestions about the disposition of used hospital rubber:

It would be my suggestion that you sell your hospital's scrap rubber, including that from sheeting, hot water bottles, rubber gloves, tubing, etc., to any scrap dealer who will give you the best price for it. In that way it will find a route to the reclaiming plants and the hospital will obtain some salvage value from it. Market prices of scrap rubber fluctuate the same as do prices of any other commodities. Further, different prices for the same grades will prevail in different communities because of differences in shipping costs that must be incurred to get the rubber to points where it can be reclaimed. Speaking generally, however, the types of scrap rubber which a hospital can accumulate will vary in price from less than a cent a pound to several cents per pound, with gloves and other "pure gum" articles commanding the higher prices. If the scrap is sorted by articles or grades of rubber, it should bring more than if sold in one bulk lot.

THE INVISIBLE RAY

The Roentgenologist is the magician of modern medicine. He is the modern Aladdin, the genii of whose magic bottle is the mysterious x-ray. Truly he looks into the crystal and predicts the future. By his wizardry we may look at the beating heart, the stone in the kidney, the ulcer crater and the distorted physiology of malignancy.

The radiologist will show you, in stereoscopic projection, the mysteries of tuberculosis—the cavity—the infiltration of infection—the healed and calcified battleground. He will point out the amount of necrosis in bone or the extent of the reparative process. He will demonstrate to the surgeon the results of his adjustments of fractures and will predict what the future should bring. One of the most dramatic phases of all surgery is to us, the setting of a fracture under the fluoroscope.

Within his darkened cave this modern Merlin conjures up more wonders than all the ancient necromancers. He will make visible the passage

of opaque fluid through the entire gastrointestinal tract and indicate any variance from the normal. He will locate with surprising accuracy hidden foreign bodies and will treat with the magic of his ray—skin lesions and deep lying malignant processes.

How many things of supreme importance in our daily medical lives do we take for granted. Scarcely ever do we stop and look back over the shoulder to see how far we have come along the highway of progress. It is wise, now and again, to give thought to the things we of this Age of Wonders accept as commonplace. Two things of today are to us of absorbing interest—the perpetual miracle of a radio—the mystery of the x-ray.

Let us pause to pay tribute to this tireless group of scientists—The Roentgenologists. Those men who stand beside the physician and surgeon and give all out assistance in the problems of disease. These men work at great personal risk—but you will never hear one of them admit it. They are the real magicians of modern medicine—they deal in scientific sorcery.—Bernard McDougall. (Editorial. *Detroit Med. News*, May 12, 1941, *32*, 8.)

LIST OF PHYSICISTS

In a report of the Committee on Safety and Standards presented at the Forty-first Annual Meeting of the American Roentgen Ray Society held in Boston in 1940, the following physicists were approved by the Committee. It also recommended that the list be published in the Journal for reference.

Blatz, I. H., Dept. of Hospitals, 414 E. 26th St., New York, N. Y.
Braestrup, C. B., Dept. of Hospitals, New York, N. Y.
Cole, K. S., College of Physicians and Surgeons, New York, N. Y.
Corrigan, K. E., Harper Hospital, Detroit, Mich.
Demers, J., University of Montreal, Montreal, Canada.
Exner, F. M., Crocker Institute, New York, N. Y.
Failla, G., Memorial Hospital, New York, N. Y.
Glasser, Otto, Cleveland Clinic, Cleveland, Ohio.
Harrington, E. L., University of Saskatchewan, Saskatoon, Canada.
Henderson, G. H., Dalhousie University, Halifax, Nova Scotia, Canada.
Henny, G. C., Temple University Hospital, Philadelphia, Pa.
Jacobson, Lillian E., Montefiore Hospital, New York, N. Y.
Laurence, G. C., National Research Council of Canada, Ottawa, Canada.
Lauritsen, C. C., California Institute of Technology, Pasadena, Calif.
Landauer, R., 1317 Judson Avenue, Highland Park, Ill.
Leppard, L. B., Department of Health, Province of Ontario, Toronto, Canada.
Macdonald, P. A., Cancer Relief and Research Institute, Winnipeg, Manitoba, Canada.
Marinelli, L. D., Memorial Hospital, New York, N. Y.
Morgan, J. S., Duke University, Durham, N. C.
Mutscheller, A., Post-Graduate Hospital, New York, N. Y.
Nurnburger, C. E., Redmon, Ill.
Omberg, A. C., Vanderbilt University Hospital, Nashville, Tenn.
O'Neill, Dallet B., Moore School, X-ray Laboratory, Philadelphia, Pa.
Pugh, R. E., 1944 Summit Avenue, Pasadena, Calif.
Quimby, Edith H., Memorial Hospital, New York, N. Y.
Reinhard, M. C., State Institute for Study of Malignant Disease, Buffalo, N. Y.
Robertson, J. K., Canada.
Rose, J. E., Marine Hospital, Baltimore, Md.
Rovner, L., Ryerson Laboratory, University of Chicago, Ill.
Schwarzschild, M. M., Beth Israel Hospital, New York, N. Y.
Shrum, G. M., University of British Columbia, Vancouver, B. C.
Sidhu, S. S., University of Pittsburgh, Pittsburgh, Pa.
Singer, G., National Bureau of Standards, Washington, D. C.
Stenstrom, W., University of Minnesota, Minneapolis, Minn.
Stephenson, B. R., Buffalo City Hospital, Buffalo, N. Y.
Taylor, Lauriston S., National Bureau of Standards, Washington, D. C.
Ulrey, C. T., Bloomfield, N. J.
Vigness, Irwin, University of Minnesota, Minneapolis, Minn.
Warren, S. Reid, Moore School, X-ray Laboratory, Philadelphia, Pa.
Weatherwax, J. L., Philadelphia General Hospital, Philadelphia, Pa.
Williams, M. M. D., Mayo Clinic, Rochester, Minn.

LOUISIANA RADIOLOGICAL SOCIETY

On April 22, 1941, a group of roentgenologists of Louisiana met and organized the Louisiana Radiological Society. The following officers were elected: *President:* Dr. Stakely F. Hatchette, Lake Charles; *Vice-President:* Dr. L. A. Fortier, New Orleans; *Secretary-Treasurer:* Dr. Johnson R. Anderson, Shreveport. The Society meets annually during the time and place of the Louisiana State Medical Society. The next meeting will be in New Orleans in April, 1942.

CLEVELAND RADIOLOGICAL SOCIETY

At the meeting of the Cleveland Radiological Society held on April 28, 1941, the following officers were elected for the coming year: *President:* Dr. H. A. Mahrer, Cleveland; *Vice-President:* Dr. E. C. Baker, Youngstown; *Secretary-Treasurer:* Dr. J. O. Newton, East Cleveland. Meetings are held at 6:30 P.M. at the Midday Club in the Union Commerce Building on the fourth Monday of each month from October to April inclusive.

PITTSBURGH ROENTGEN SOCIETY

On Saturday evening May 10, 1941, at a dinner meeting at the Hotel William Penn in Pittsburgh, the Pittsburgh Roentgen Society was addressed by Dr. Murray M. Copeland of Baltimore. The meeting was well attended and Dr. Copeland, who is a co-author of "Tumors of Bone," spoke on the subject "The Prognosis of Bone Tumors." He pointed out the importance of proper classification and early radical treatment such as is used in any other highly malignant condition.

ILLINOIS RADIOLOGICAL SOCIETY

At a recent meeting of the Illinois Radiological Society the following officers were elected for the ensuing year: *President:* Dr. E. L. Rypins, Bloomington; *Vice-President:* Dr. P. R. Dirkse, Peoria; *Secretary:* Dr. Wm. DeHollander, Springfield. Meetings are held three times a year.

Vol. 45, No. 6

DEPARTMENT OF TECHNIQUE

Department Editor: Robert B. Taft, M.D., B.S., M.A., 105 Rutledge Ave.
Charleston, S. C.

MEASUREMENT OF THE TRUE CONJUGATE WITH THE AID OF A NEW LIGHTWEIGHT RULE

By HARRY J. PERLBERG, M.D., F.A.C.P.
Department of Roentgenology, Margaret Hague Maternity Hospital
HUDSON COUNTY, NEW JERSEY

MEASUREMENT in centimeters of the true conjugate of the maternal pelvis by means of a brass rule attached to the patient's back with adhesive plaster was first described by Weitzner.[1] The principle involved was that the distortion of the dots in the rule was equivalent to the distortion of the pelvis in the plane of the true conjugate. The distance between any two points on the image of the pelvis could therefore be measured in centimeters by applying the actual distance between them to the image of the rule. This rule is attached to the patient's back over the spinous processes of the lumbar spine and sacrum, the lower end of the rule lying in the cleft between the buttocks. A lateral roentgenogram is made

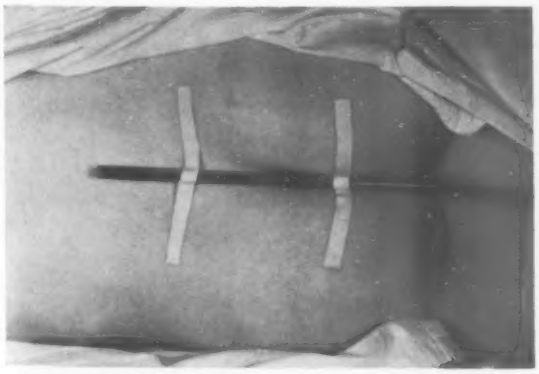


Fig. 1. Photograph of patient with rule in situ.

to show the lumbar spine, the sacrosciatic notch, and profile of the true conjugate.

[1] Weitzner, S. F. Simple roentgenographic method for accurately determining true conjugate diameter of pelvis. *Am. J. Obst. & Gynec.*, 1935, *30*, 126–128.

The only difficulty we have had with the Weitzner rule, which has been used for a number of years, is that due to its weight it has a tendency to slip. To overcome the slip-

Fig. 2. Lateral roentgenogram of pelvis showing shadow of rule in relationship to pelvis.

ping we mounted the rule upon two uprights which were adjustable and placed the rule directly parallel with the spinous processes of the patient, but it was found that the patient would very frequently rotate slightly so that unequal distortion between the plane of the true conjugate and that of the rule resulted.

We have made a lightweight rule of hollow bakelite with lead and bakelite strips

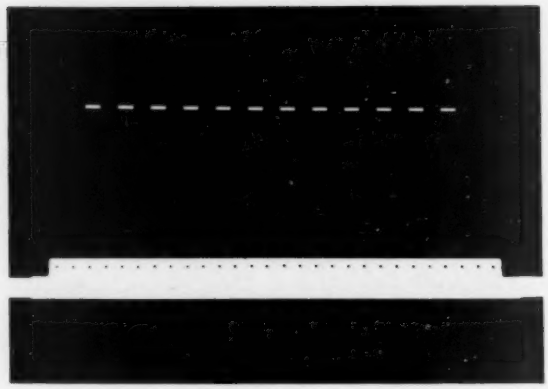


FIG. 3. Roentgenographic comparison of new and old rules showing increased legibility of new rule. Each white and black space measures exactly 1 cm. on the rule.

alternately inserted into the hollow, the lead inserts accurately marking off distances of 1 cm. This rule measures $\frac{3}{8}$″ in width by 10″ in length. It is strapped to the patient's back in the same manner as the Weitzner rule but due to its light weight there is not enough pull against the adhesive to permit of any slipping, assuring accurate measurement.

The weight of the bakelite rule is 1 ounce as against the weight of the brass rule which is 12 ounces. Comparison of images of the brass and the bakelite rules shows that it is much less difficult to read the spaces with the lighter rule, the lead strips showing greater opacity on the film.

The advantages are its lightness, the fact that it can be readily applied to the patient's back where it stays without slipping and the fact that the spaces are more clearly discerned and more easily read than the dots or notches on the brass rule.

I wish to express thanks to Dr. Robert Berman and also to Mr. Robert Taylor, Chief Technician of the Department, for their interest.

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(abs) = abstract (E) = editorial

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